US009483018B2

(12) **United States Patent**
**Hirasawa et al.**

(10) **Patent No.: US 9,483,018 B2**
(45) **Date of Patent: Nov. 1, 2016**

(54) **COOLING DEVICE AND IMAGE FORMING APPARATUS INCLUDING SAME**

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(72) Inventors: **Tomoyasu Hirasawa**, Kanagawa (JP); **Kenichi Takehara**, Kanagawa (JP); **Hiromitsu Fujiya**, Kanagawa (JP); **Keisuke Yuasa**, Kanagawa (JP); **Yasuaki Toda**, Kanagawa (JP); **Yutaka Shoji**, Kanagawa (JP); **Kenji Ishii**, Ibaraki (JP); **Makoto Nakura**, Ibaraki (JP); **Susumu Tateyama**, Ibaraki (JP); **Hiroaki Miyagawa**, Ibaraki (JP); **Keisuke Ikeda**, Kanagawa (JP); **Takeshi Watanabe**, Ibaraki (JP)

(73) Assignee: **Ricoh Company, Ltd.**, Tokyo (JP)

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/924,148**

(22) Filed: **Oct. 27, 2015**

(65) **Prior Publication Data**

US 2016/0048106 A1 Feb. 18, 2016

**Related U.S. Application Data**

(63) Continuation of application No. 14/140,888, filed on Dec. 26, 2013, now Pat. No. 9,217,979.

(30) **Foreign Application Priority Data**

Dec. 27, 2012 (JP) ................................ 2012-285722
Mar. 4, 2013 (JP) ................................ 2013-041649
Jul. 8, 2013 (JP) ................................ 2013-142510

(51) **Int. Cl.**

| | |
|---|---|
| ***G03G 15/20*** | (2006.01) |
| ***G03G 21/20*** | (2006.01) |
| ***G03G 15/00*** | (2006.01) |

(52) **U.S. Cl.**

CPC .......... ***G03G 21/20*** (2013.01); ***G03G 15/6529*** (2013.01); ***G03G 15/6573*** (2013.01); *G03G 15/2021* (2013.01); *G03G 2215/0129* (2013.01)

(58) **Field of Classification Search**

CPC ............. G03G 21/20; G03G 15/2021; G03G 2215/0129; G03G 15/6573; G03G 15/6529; B41J 29/377

USPC .................................................. 399/341, 407

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,960,242 A 9/1999 Greive
5,970,301 A 10/1999 De Cock

(Continued)

FOREIGN PATENT DOCUMENTS

JP 08-129310 A 5/1996
JP 10-221976 8/1998

(Continued)

OTHER PUBLICATIONS

Machine translation of JP 2011-057389 (publication date of Mar. 24, 2011) printed on Nov. 20, 2015.*

(Continued)

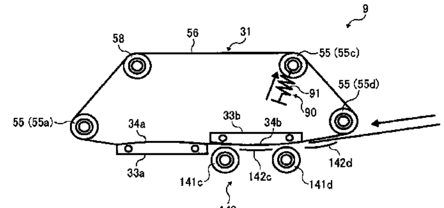
*Primary Examiner* — Sophia S Chen

(74) *Attorney, Agent, or Firm* — Oblon, McClelland, Maier & Neustadt, L.L.P.

(57) **ABSTRACT**

A recording-material cooling device includes a first belt, a first cooling unit, and a second cooling unit. The first belt is disposed at a first face side of a recording material. The first cooling unit has a first heat absorbing surface to contact the first belt to absorb heat of the recording material. The second cooling unit has a second heat absorbing surface to directly or indirectly contact the recording material to absorb heat of the recording material. The second cooling unit is disposed at a second face side of the recording material. The first and second cooling units are offset from each other in a transport direction of the recording material. Each of the first and second surfaces has a shape in which an inner area protrudes beyond opposed ends in the transport direction. The first and second surfaces overlap each other in a direction crossing the transport direction.

**13 Claims, 29 Drawing Sheets**



(56) **References Cited**

U.S. PATENT DOCUMENTS

| | | | |
|---|---|---|---|
| 2006/0171749 A1 | 8/2006 | Tomita et al. | |
| 2009/0103959 A1 | 4/2009 | Koyama et al. | |
| 2011/0064494 A1 | 3/2011 | Amita et al. | |
| 2012/0315069 A1 | 12/2012 | Ikeda et al. | |
| 2012/0328343 A1 | 12/2012 | Kunii et al. | |
| 2013/0121739 A1* | 5/2013 | Hatazaki ............ | G03G 15/2021 399/341 |
| 2013/0259512 A1 | 10/2013 | Ikeda et al. | |
| 2014/0060782 A1 | 3/2014 | Ikeda et al. | |
| 2014/0308057 A1 | 10/2014 | Tomino | |

FOREIGN PATENT DOCUMENTS

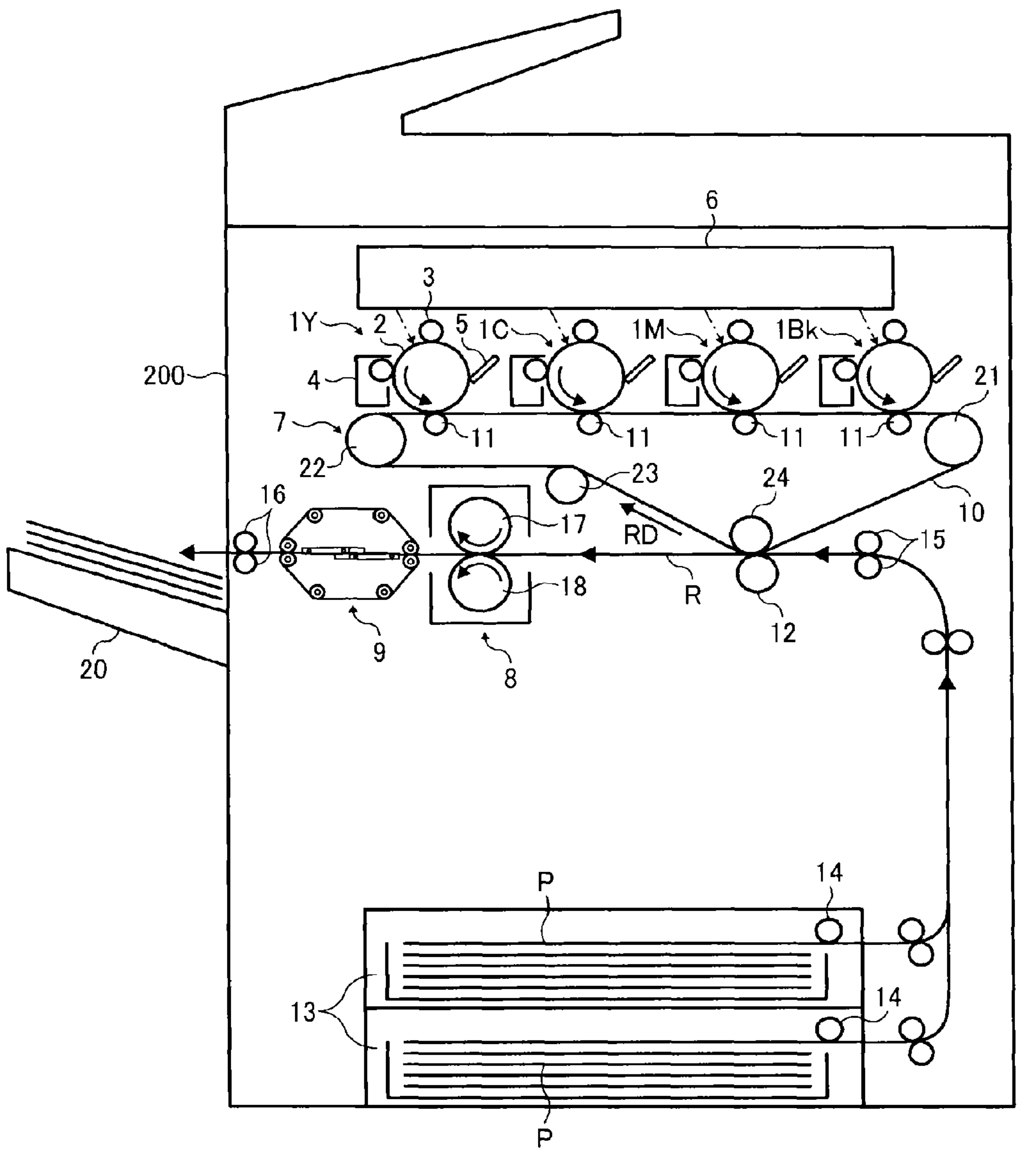
| | | |
|---|---|---|
| JP | 2004-325934 | 11/2004 |
| JP | 2005-084109 | 3/2005 |
| JP | 2006-201657 | 8/2006 |
| JP | 20007-121653 A | 5/2007 |
| JP | 2008-112102 | 5/2008 |
| JP | 2008-170541 | 7/2008 |
| JP | 2009-103822 | 5/2009 |
| JP | 2009-161347 | 7/2009 |
| JP | 2009-236953 | 10/2009 |
| JP | 2011-057389 | 3/2011 |
| JP | 2012-098677 | 5/2012 |
| JP | 2012-173640 | 9/2012 |
| JP | 2013-088564 | 5/2013 |

OTHER PUBLICATIONS

U.S. Appl. No. 13/958,014, filed Aug. 2, 2013.
Extended European Search Report issued on Aug. 7, 2014, in Patent Application No. 14163886.6.
Office Action dated Aug. 22, 2016 for Japanese Patent Application No. 2012-285722.

* cited by examiner

FIG. 1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3
1Y
2
5
1C
1M
1Bk
200
4
21
7
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11
11
22
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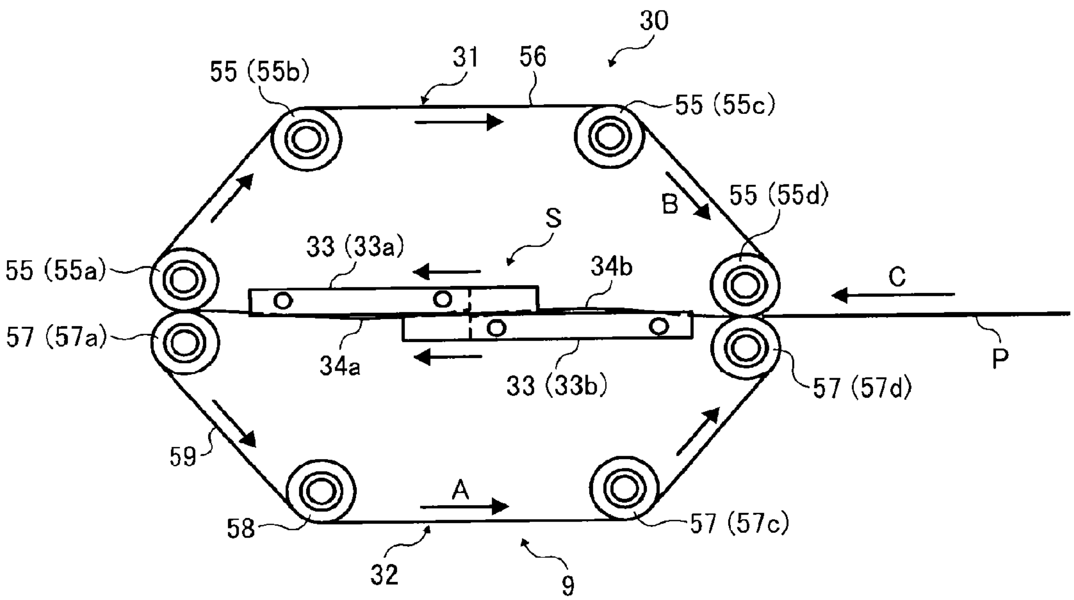
24
10
16
17
RD
15
R
18
12
9
8
20
P
14
13
14
P

FIG. 2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55 (55c)
B
55 (55d)
S
33 (33a)
34b
55 (55a)
C
57 (57a)
34a
33 (33b)
57 (57d)
P
59
A
58
57 (57c)
32
9

FIG. 3

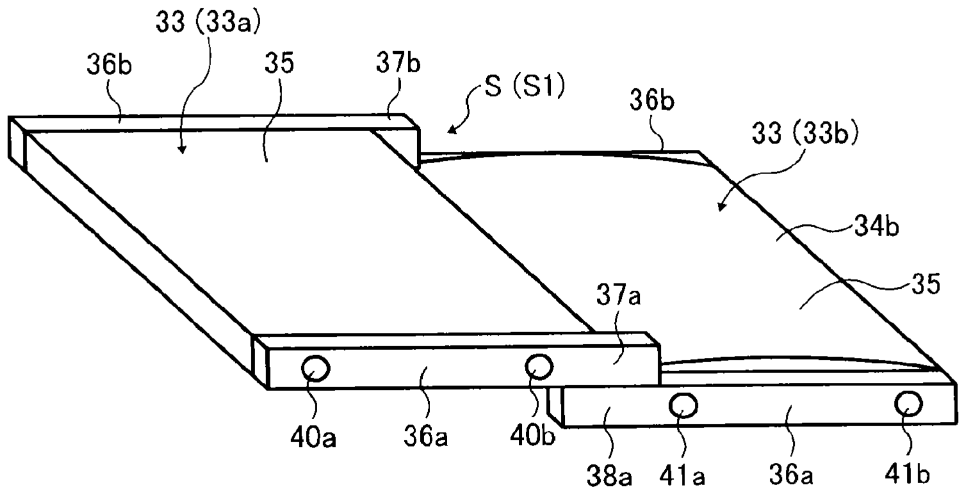

33 (33a)
36b
35
37b
S (S1)
36b
33 (33b)
34b
35
37a
40a
36a
40b
38a
41a
36a
41b

FIG. 4

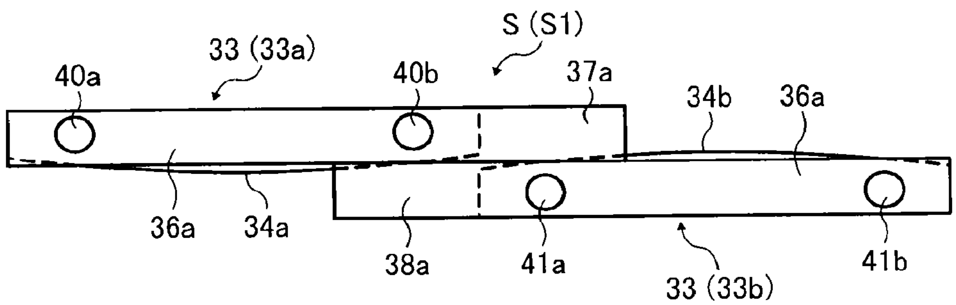

S (S1)
33 (33a)
40a
40b
37a
34b
36a
36a
34a
38a
41a
33 (33b)
41b

FIG. 5

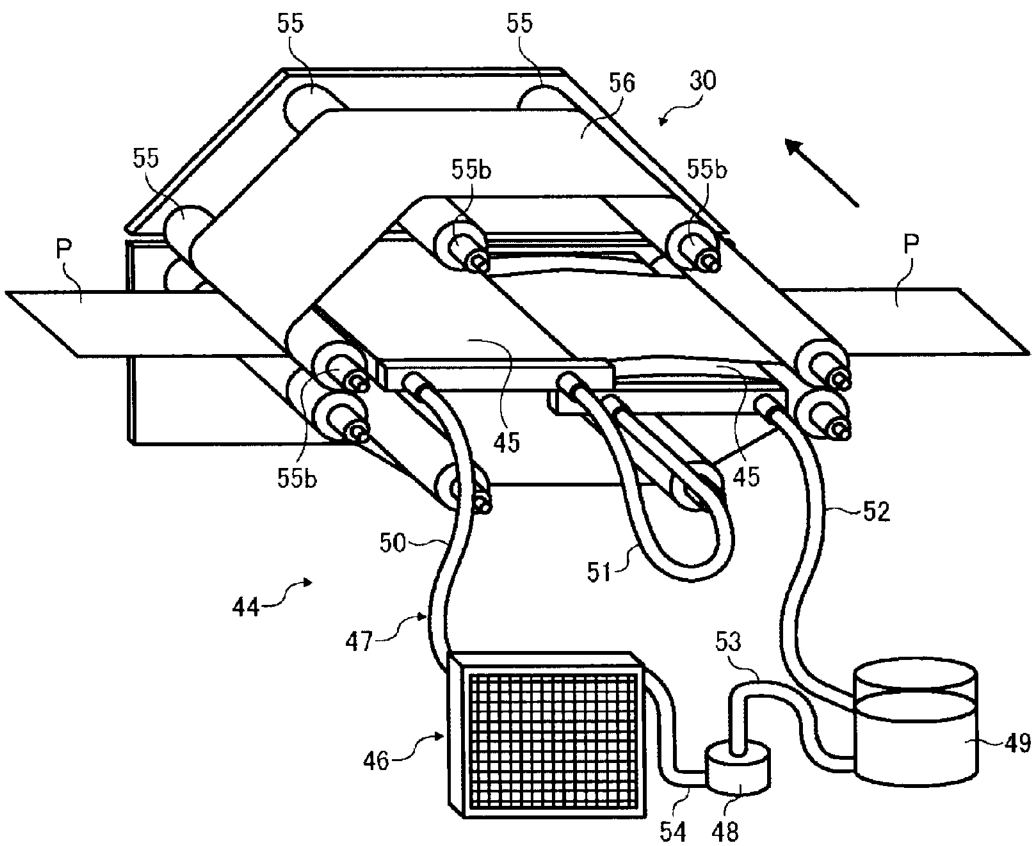


FIG. 6A

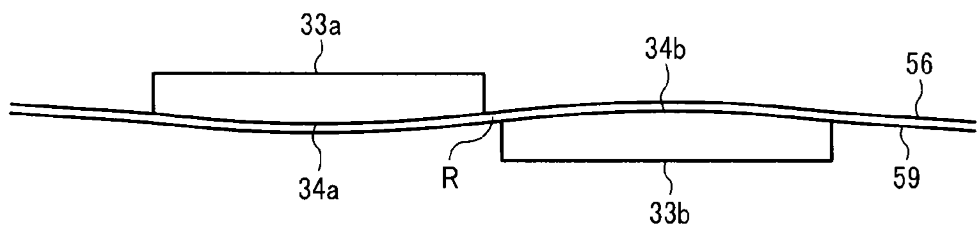
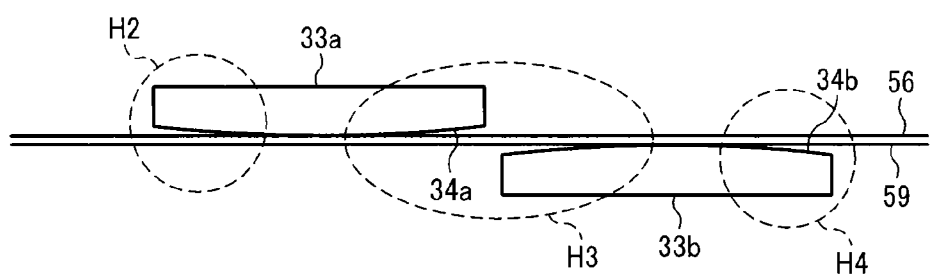



FIG. 6B




**RELATED ART**

FIG. 7A

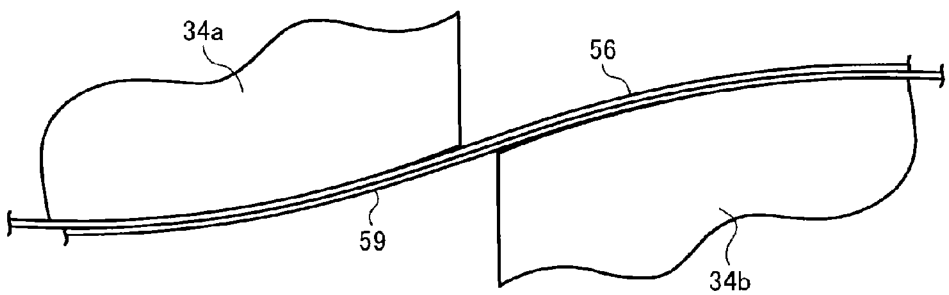



FIG. 7B

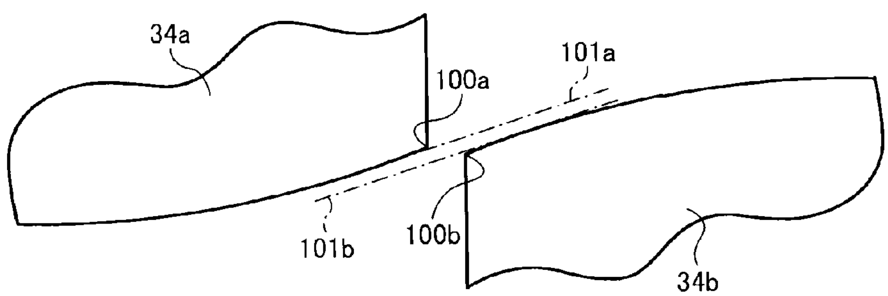



FIG. 8

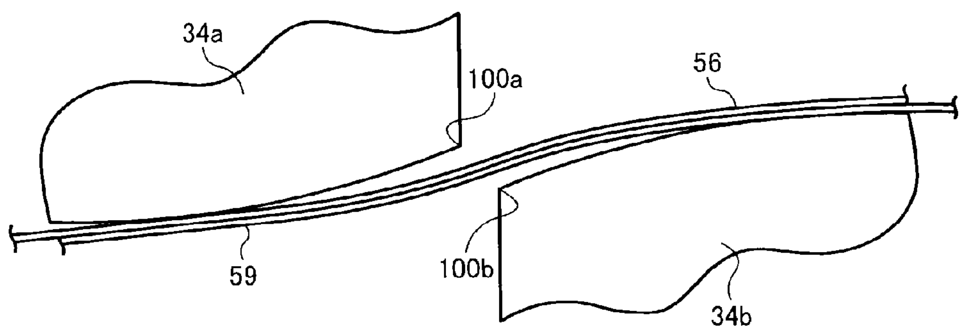


FIG. 9A

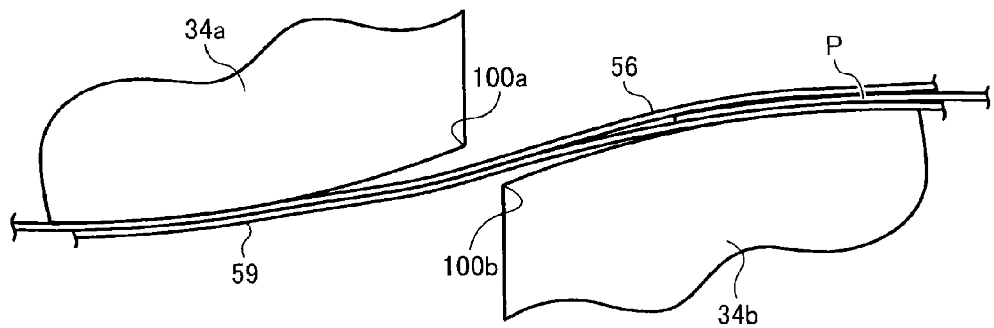



FIG. 9B

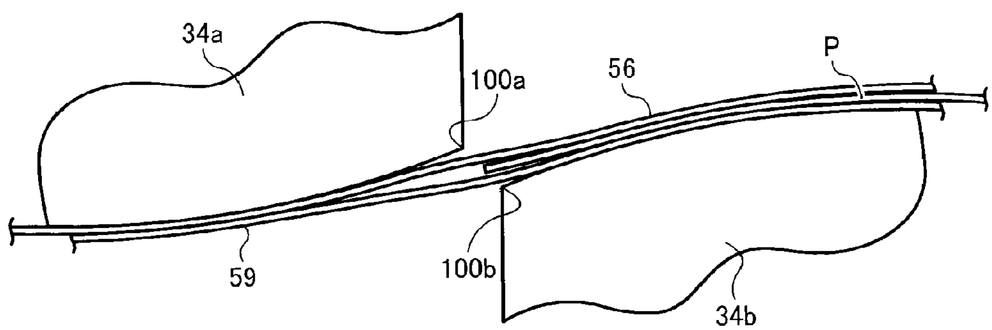



FIG. 9C

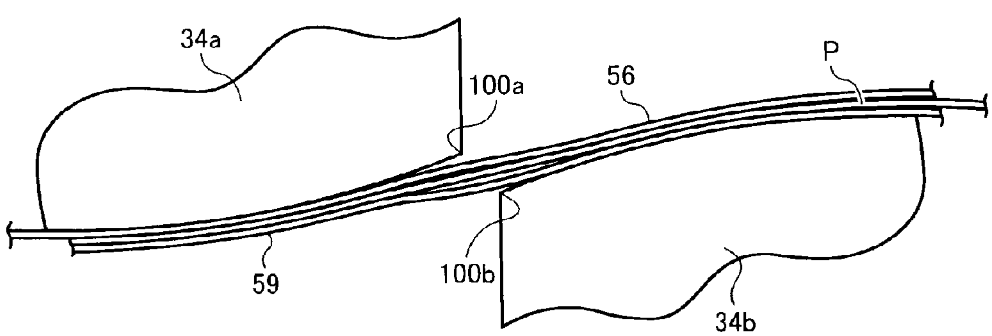


FIG. 10

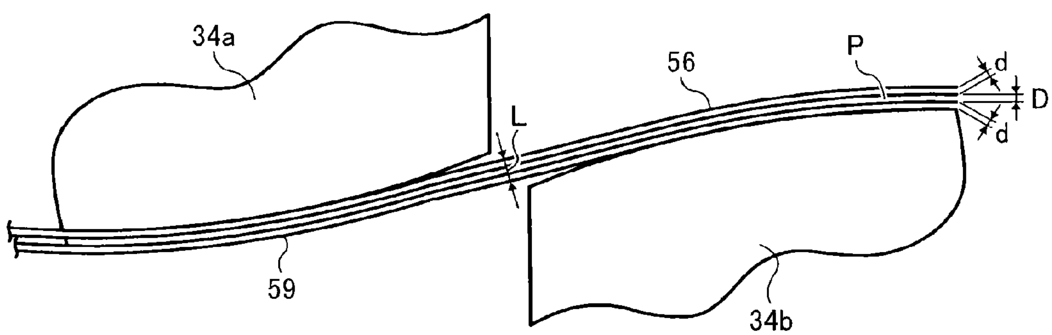



FIG. 11

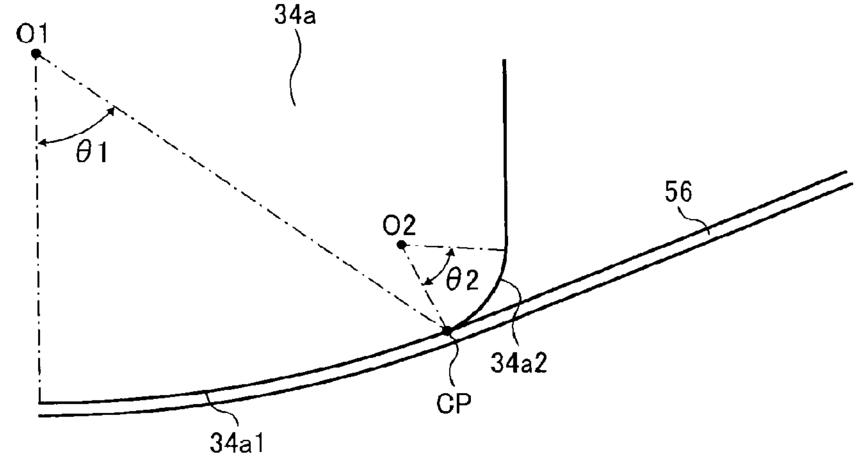


FIG. 12

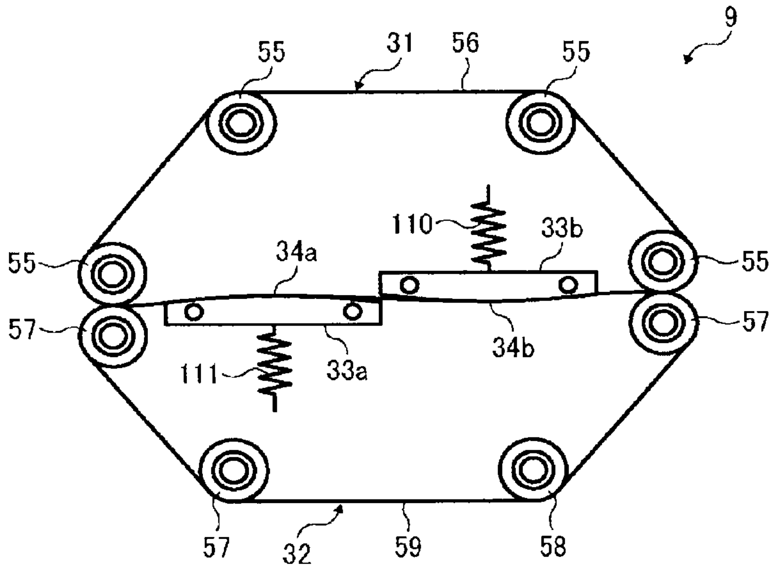

9
31
56
55
55
55
55
110
33b
34a
57
57
34b
33a
111
57
32
59
58

FIG. 13

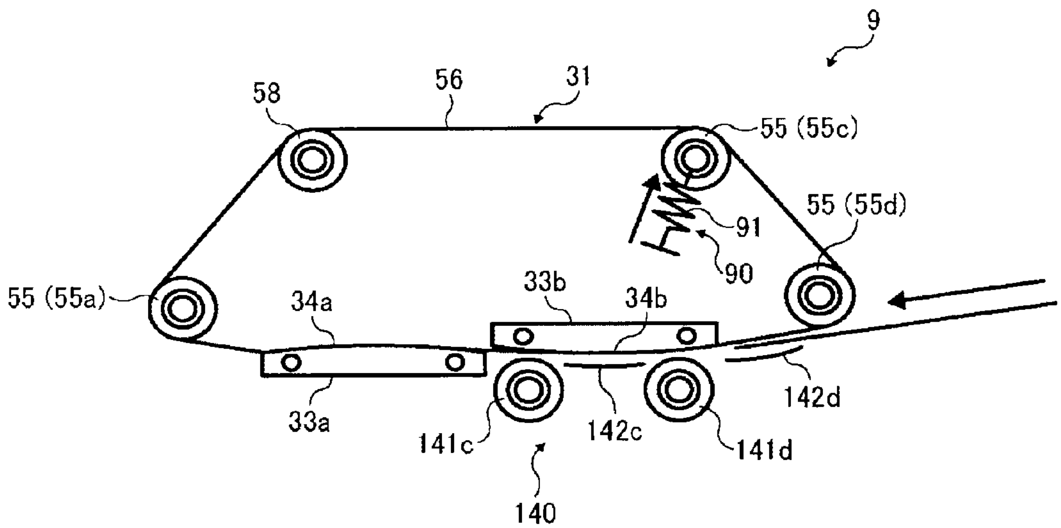
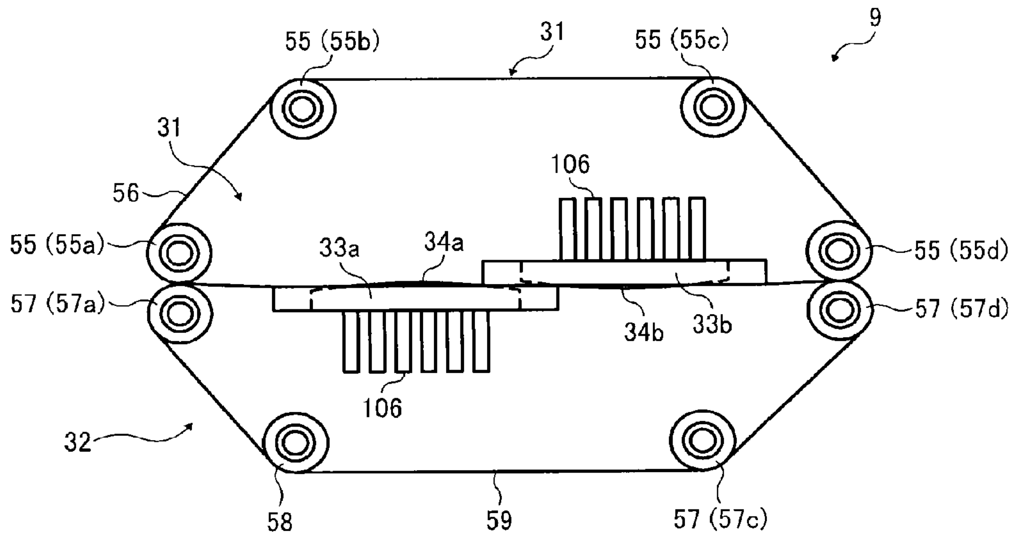
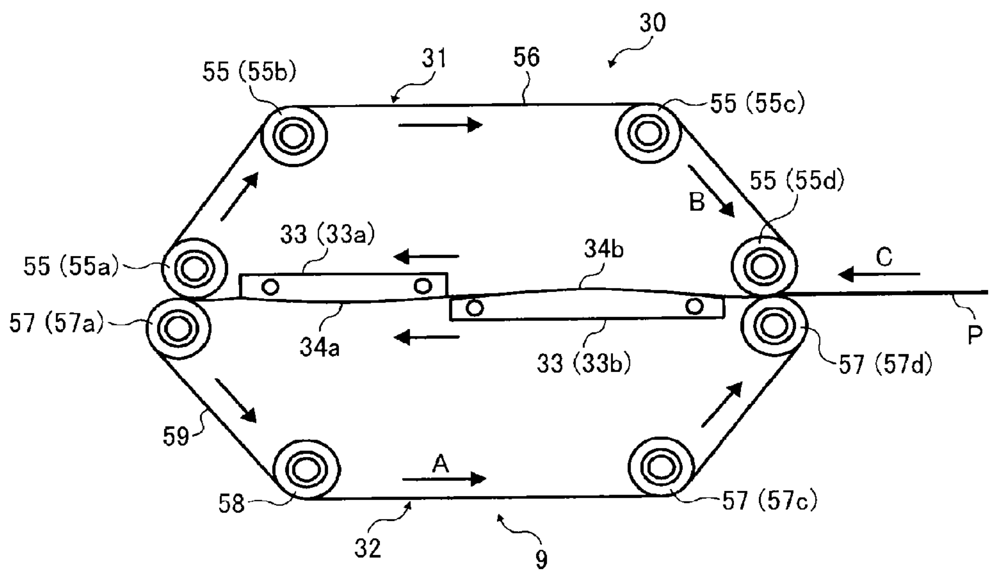

9
58
56
31
55 (55c)
55 (55d)
91
90
55 (55a)
34a
33b
34b
33a
141c
142c
141d
142d
140

FIG. 14



9
31
55 (55b)
55 (55c)
31
56
106
55 (55a)
33a
34a
55 (55d)
57 (57a)
57 (57d)
34b
33b
106
32
58
59
57 (57c)


FIG. 15



30
31
56
55 (55b)
55 (55c)
55 (55d)
B
33 (33a)
34b
C
55 (55a)
57 (57a)
34a
33 (33b)
P
57 (57d)
59
A
58
57 (57c)
32
9

FIG. 16

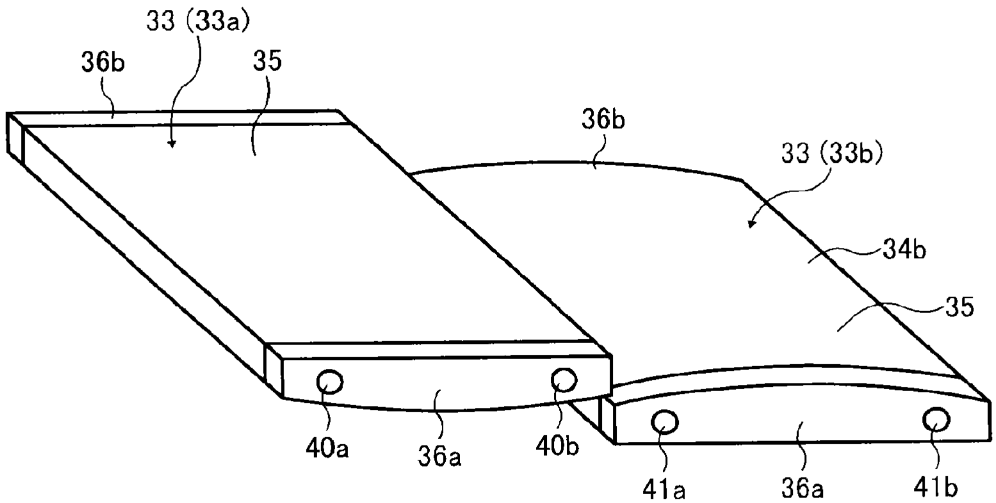

33 (33a)
36b
35
36b
33 (33b)
34b
35
40a
36a
40b
41a
36a
41b

FIG. 17

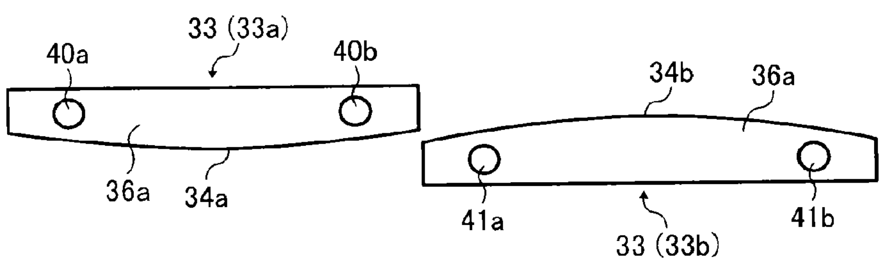

33 (33a)
40a
40b
36a
34a
34b
36a
41a
33 (33b)
41b

FIG. 18

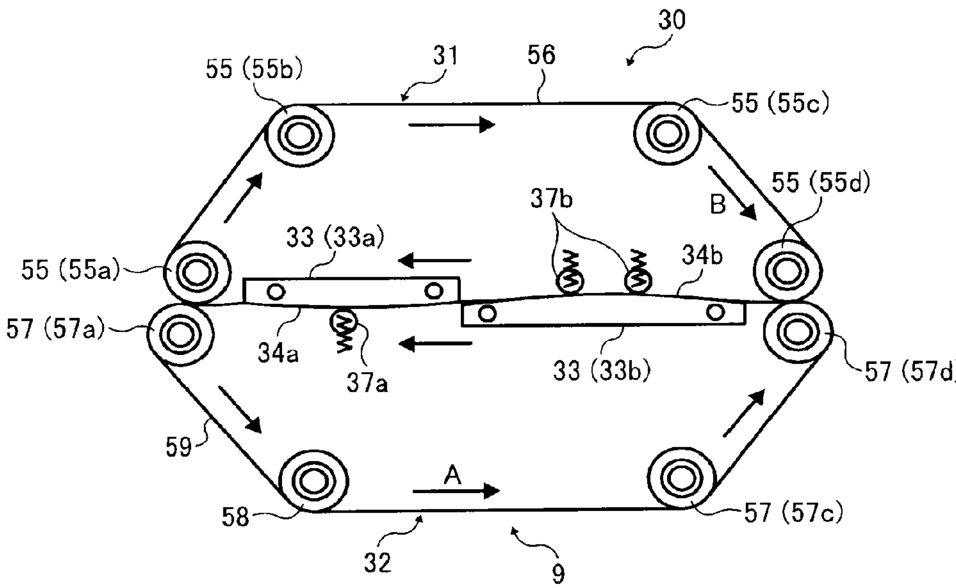
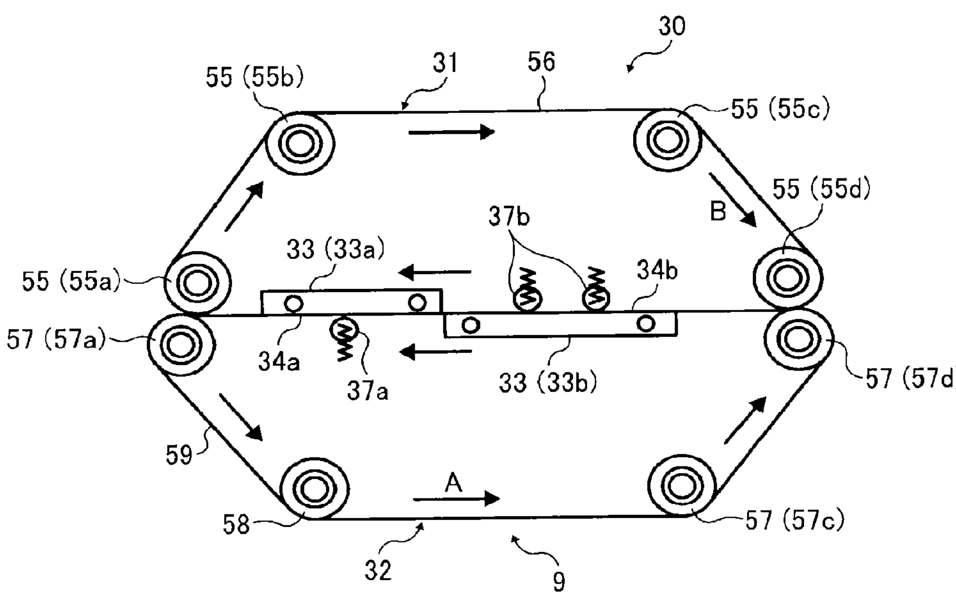

30
31
56
55 (55b)
55 (55c)
55 (55d)
B
37b
33 (33a)
34b
55 (55a)
57 (57a)
34a
37a
33 (33b)
57 (57d)
59
A
58
57 (57c)
32
9

FIG. 19


30
31
56
55 (55b)
55 (55c)
55 (55d)
B
37b
33 (33a)
34b
55 (55a)
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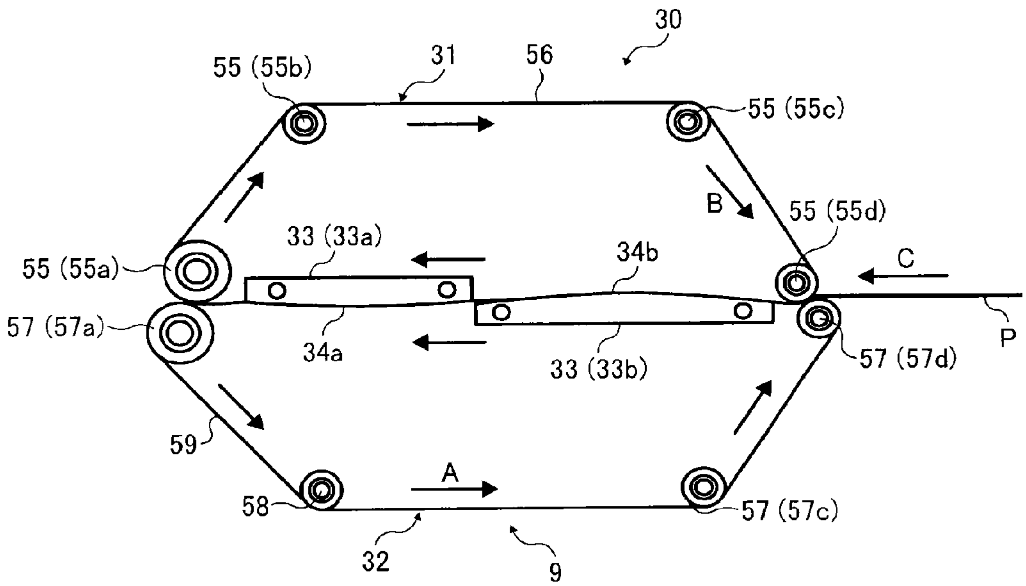
34a
37a
33 (33b)
57 (57d)
59
A
58
57 (57c)
32
9

FIG. 20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31
56
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B
55 (55d)
C
33 (33a)
34b
55 (55a)
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34a
33 (33b)
57 (57d)
P
59
A
58
57 (57c)
32
9

FIG. 21

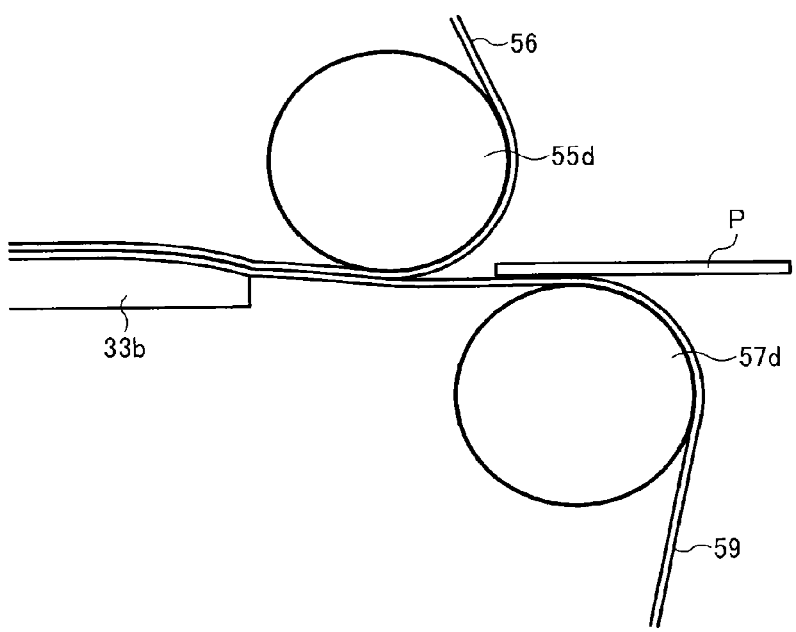

56
55d
P
33b
57d
59

FIG. 22

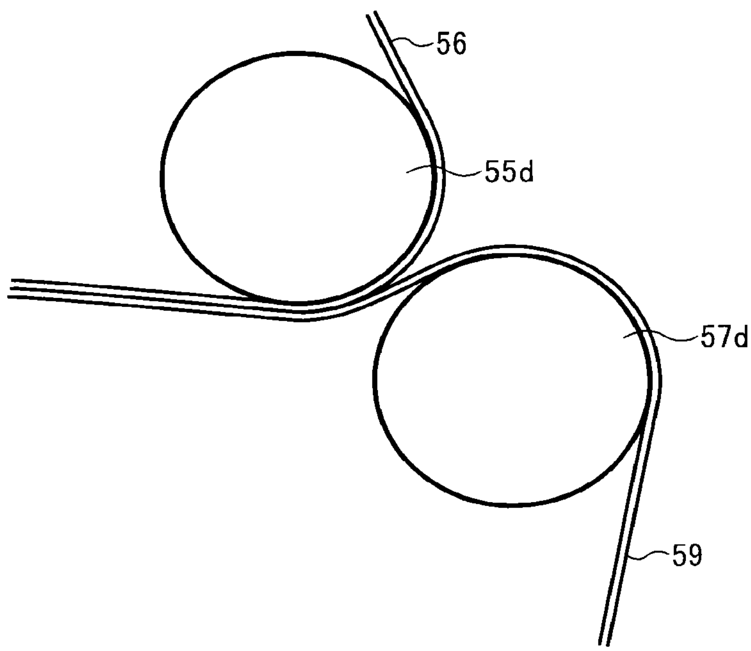
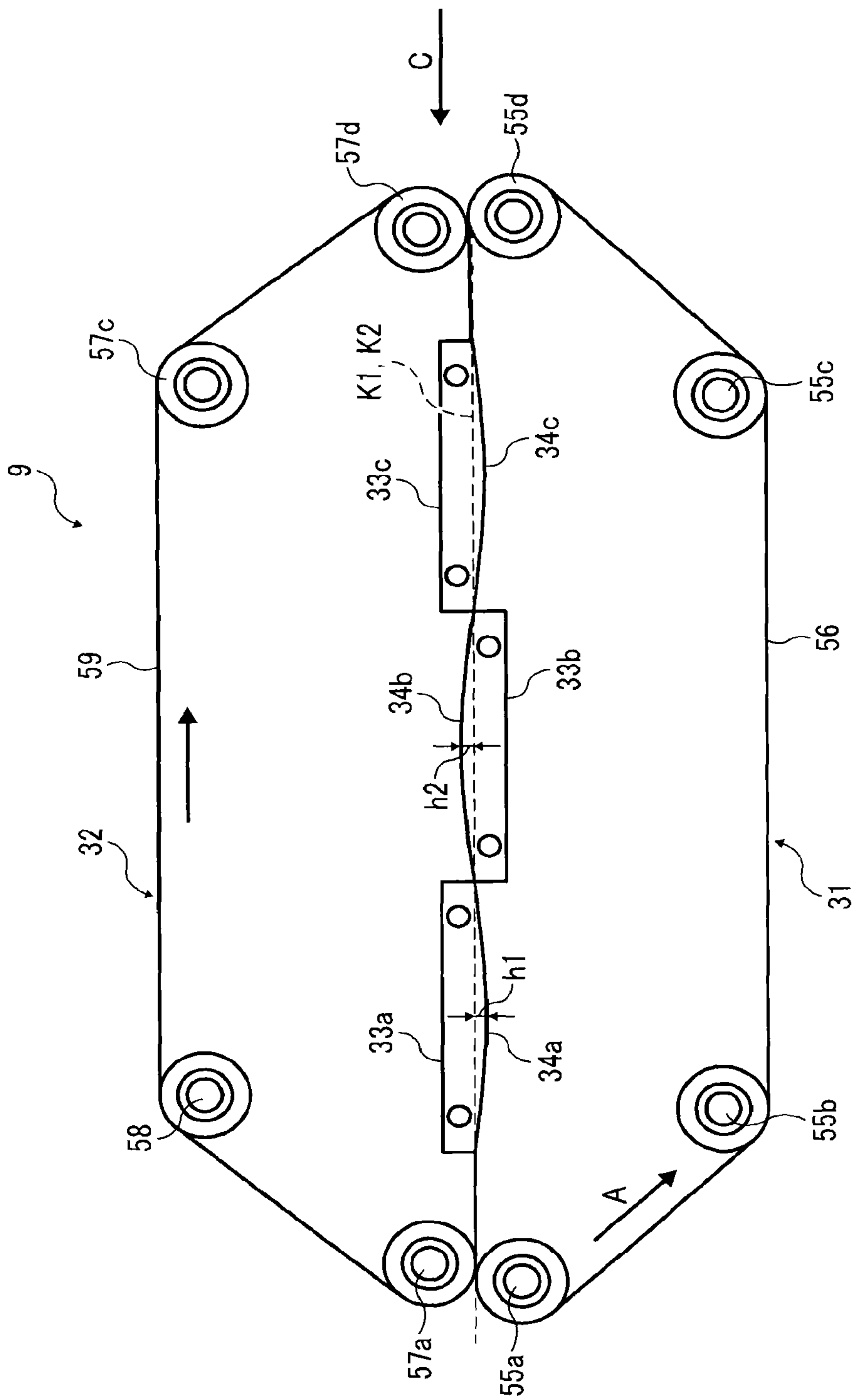
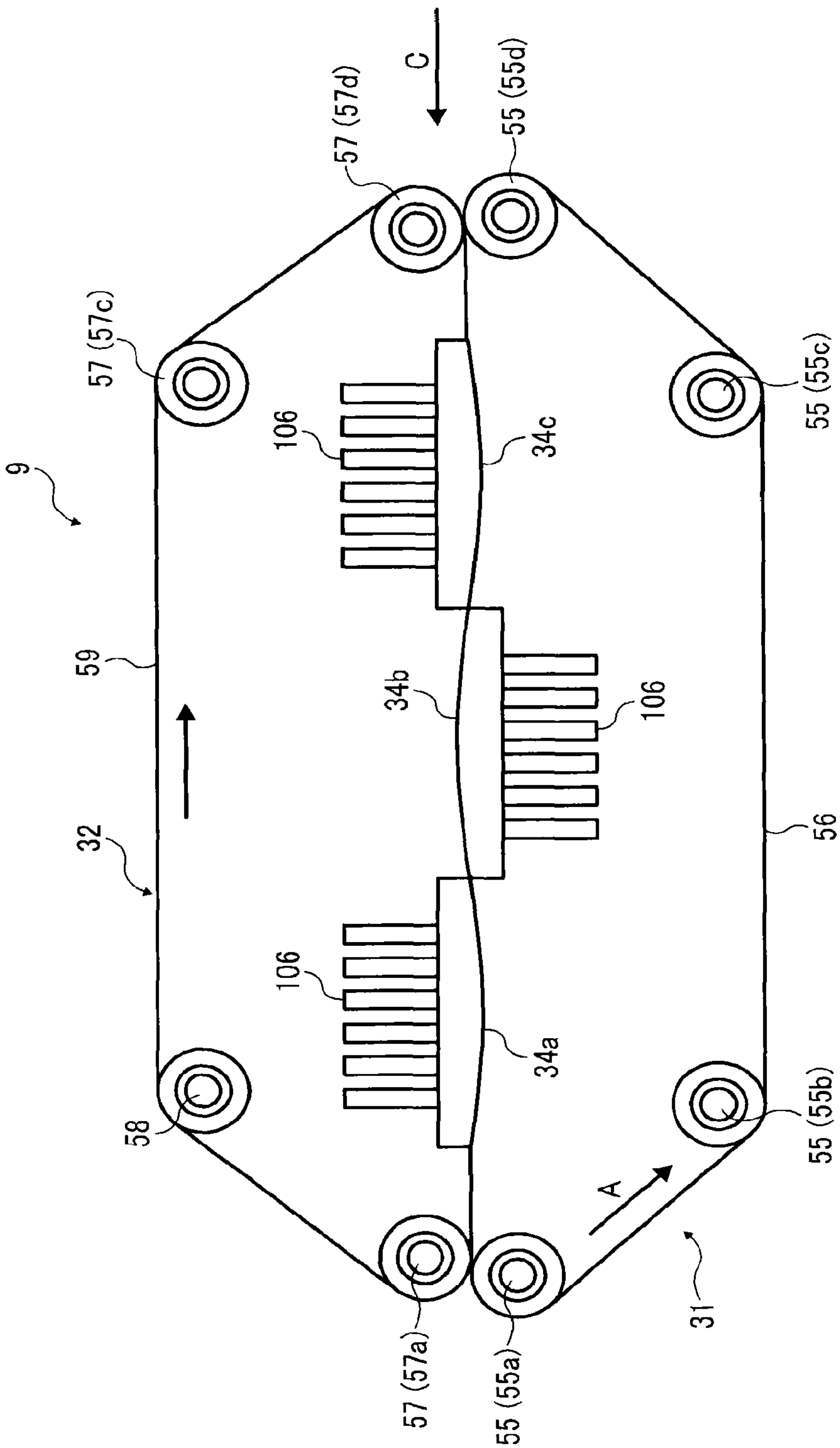


FIG. 23



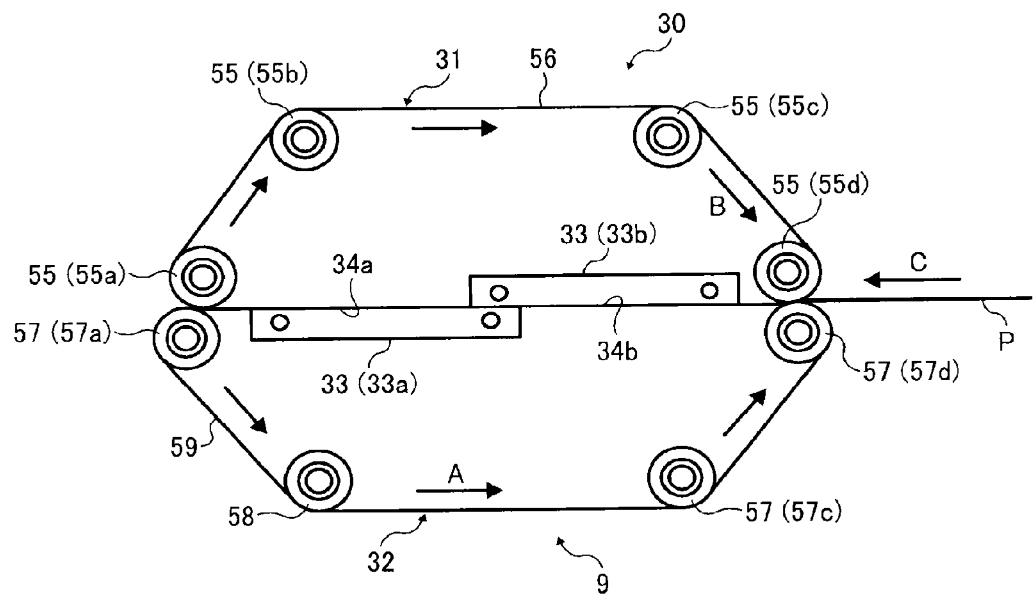
C
57d
55d
57c
K1, K2
55c
9
33c
34c
59
56
34b
33b
h2
32
31
33a
h1
34a
58
55b
A
57a
55a

FIG. 24



9
32
59
58
57 (57a)
57 (57c)
57 (57d)
C
55 (55d)
55 (55c)
55 (55b)
55 (55a)
56
31
A
106
106
106
34a
34b
34c

FIG. 25


30
31
56
55 (55b)
55 (55c)
55 (55d)
B
33 (33b)
C
55 (55a)
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34b
P
33 (33a)
57 (57d)
59
A
58
57 (57c)
32
9

FIG. 26A

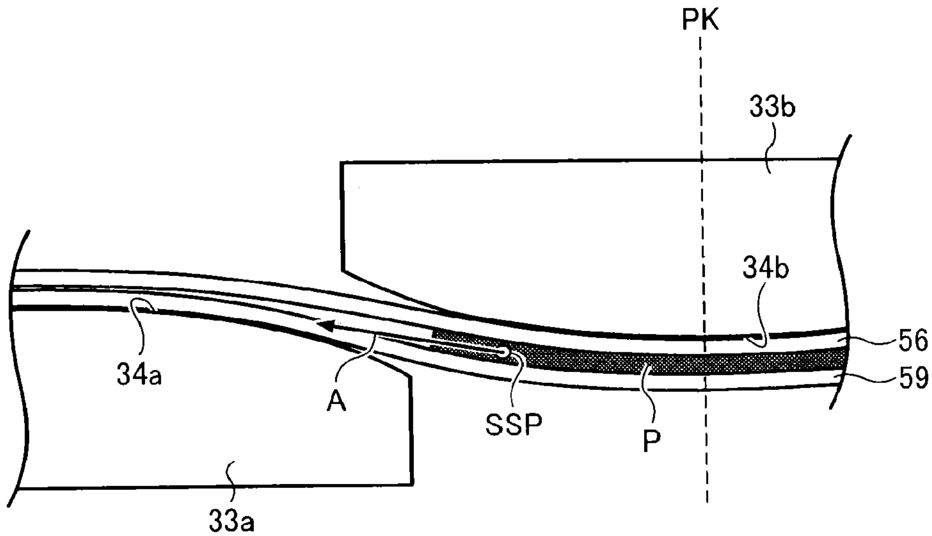
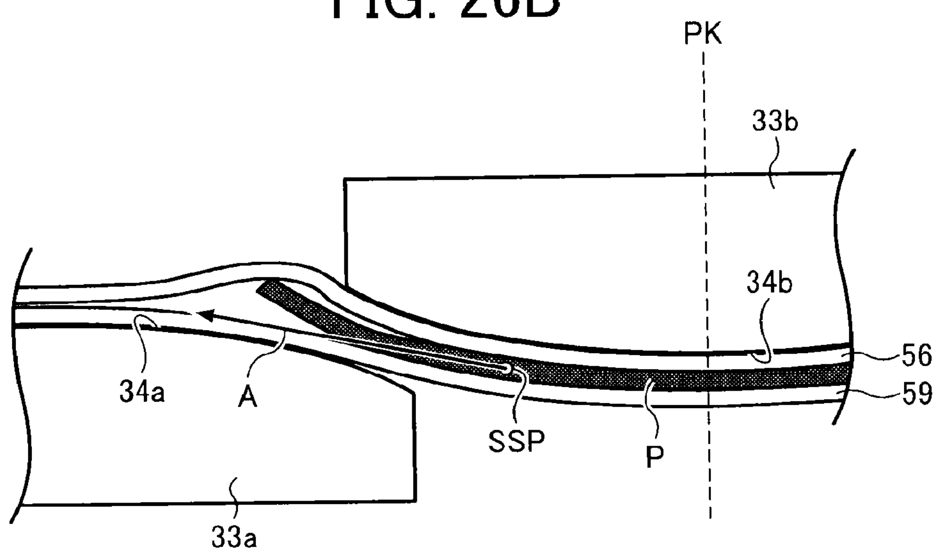



FIG. 26B



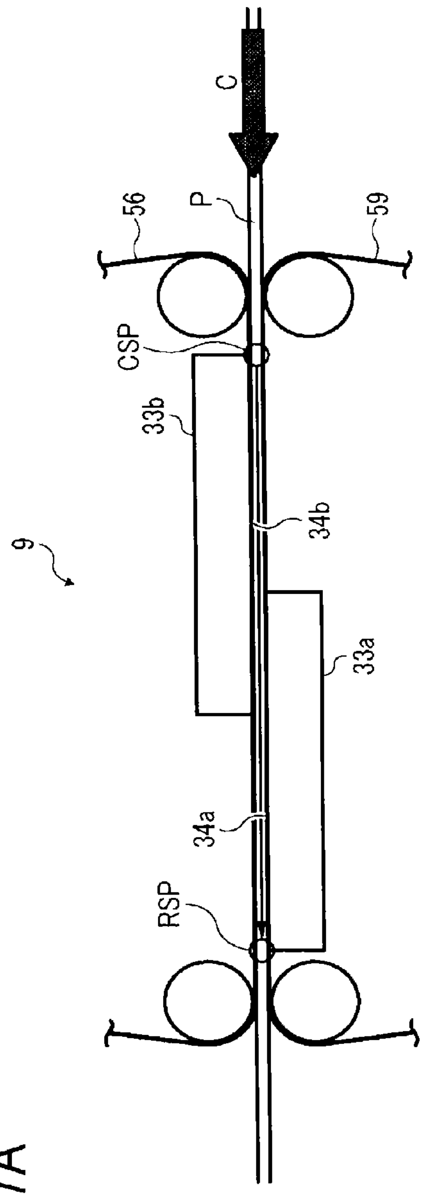



FIG. 27A

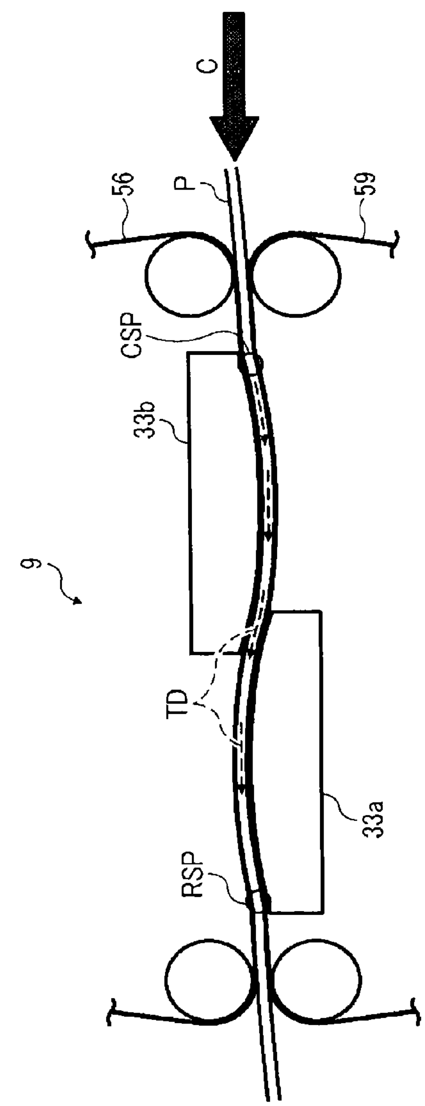



FIG. 27B

FIG. 28

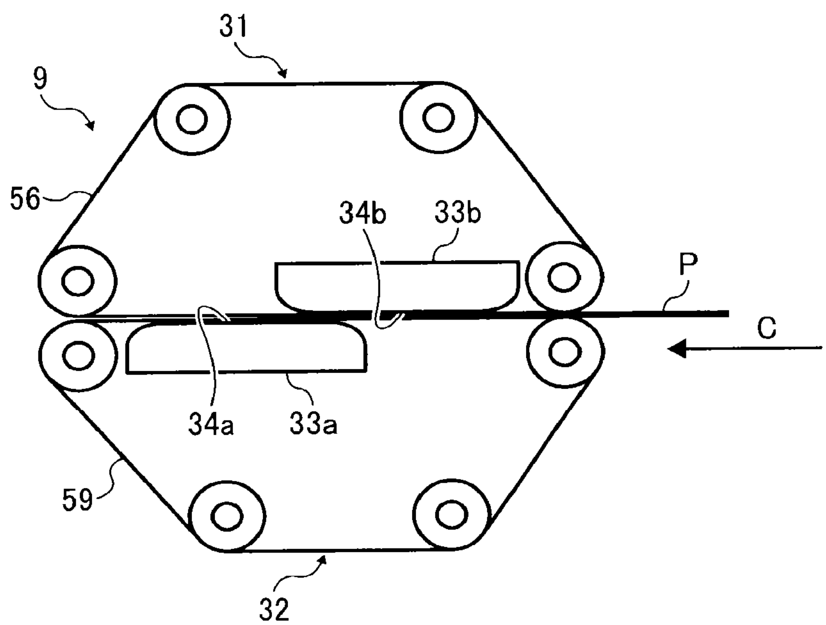


FIG. 29A

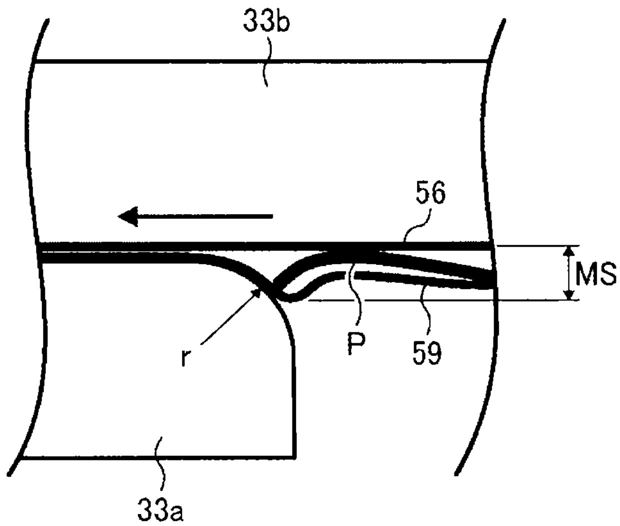



FIG. 29B

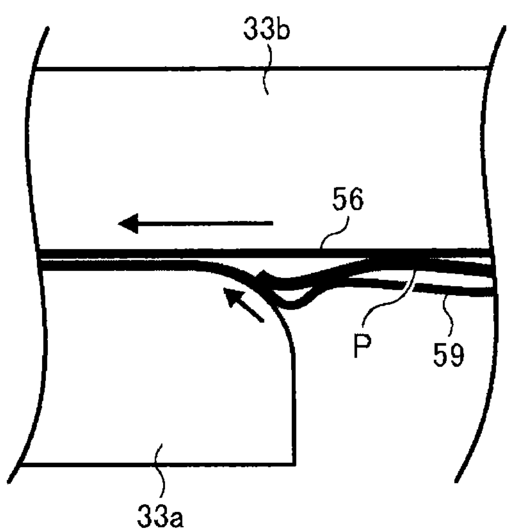


FIG. 30A

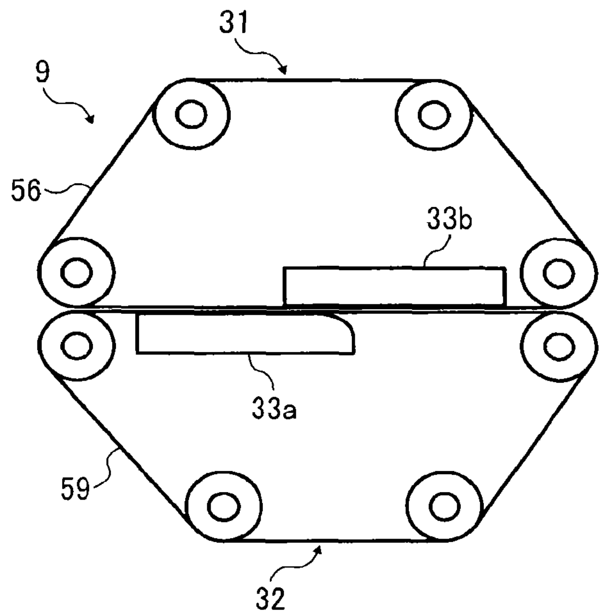



FIG. 30B

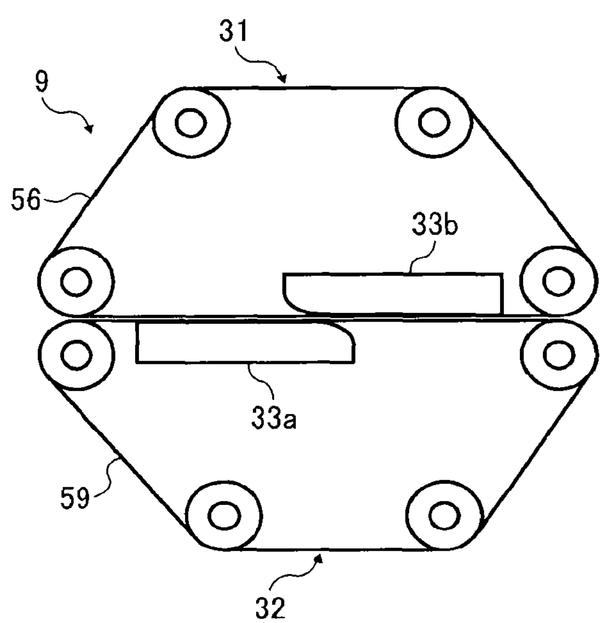


FIG. 31A

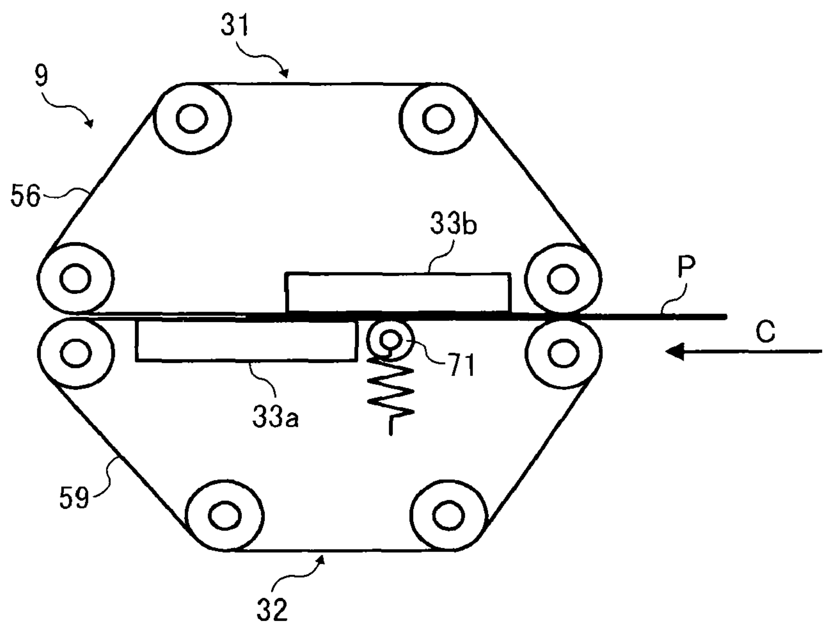



FIG. 31B

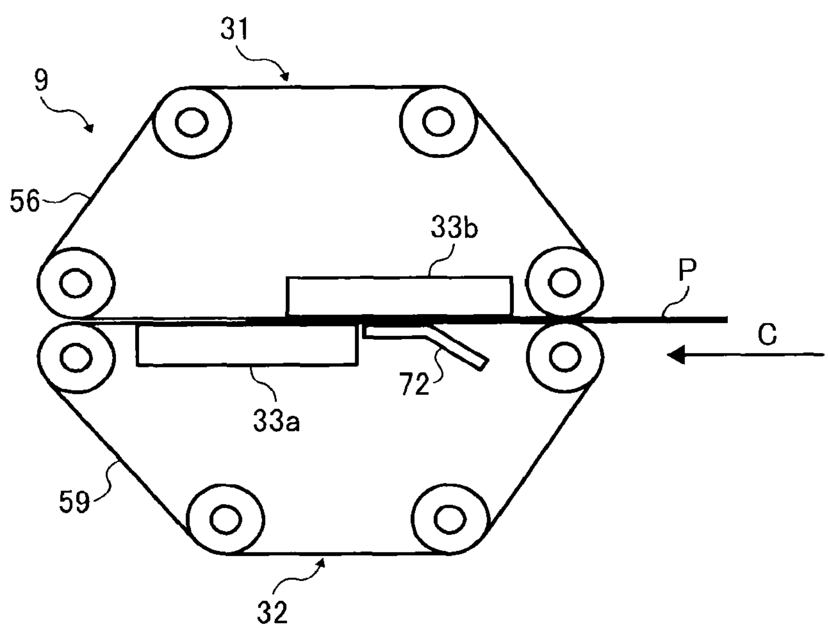


FIG. 32

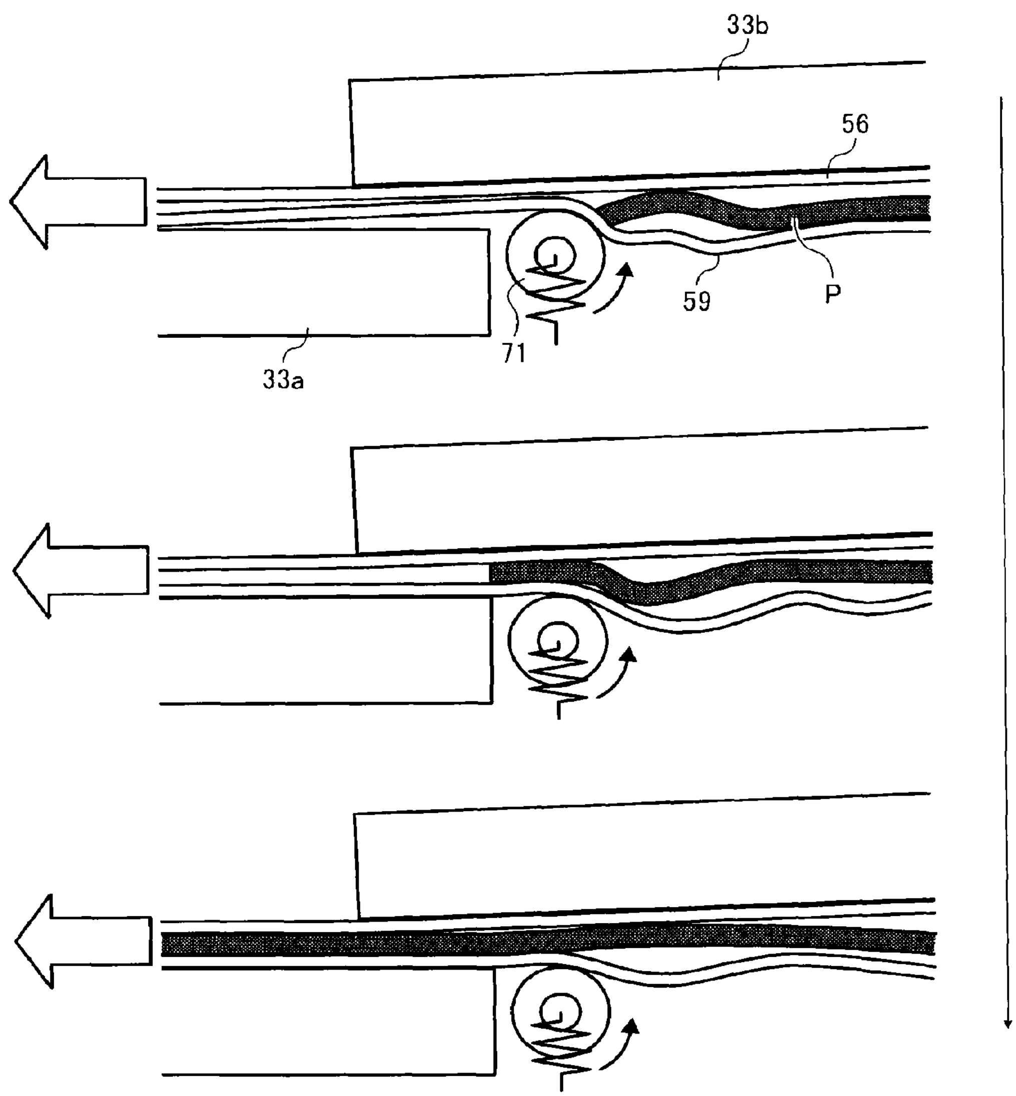
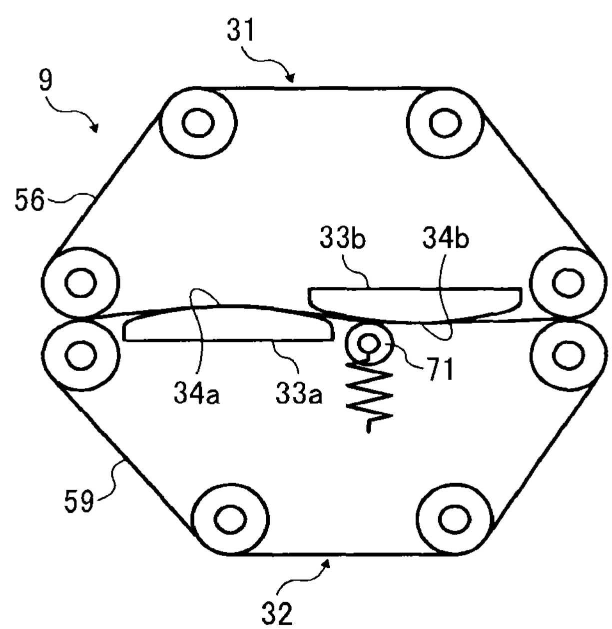


FIG. 33



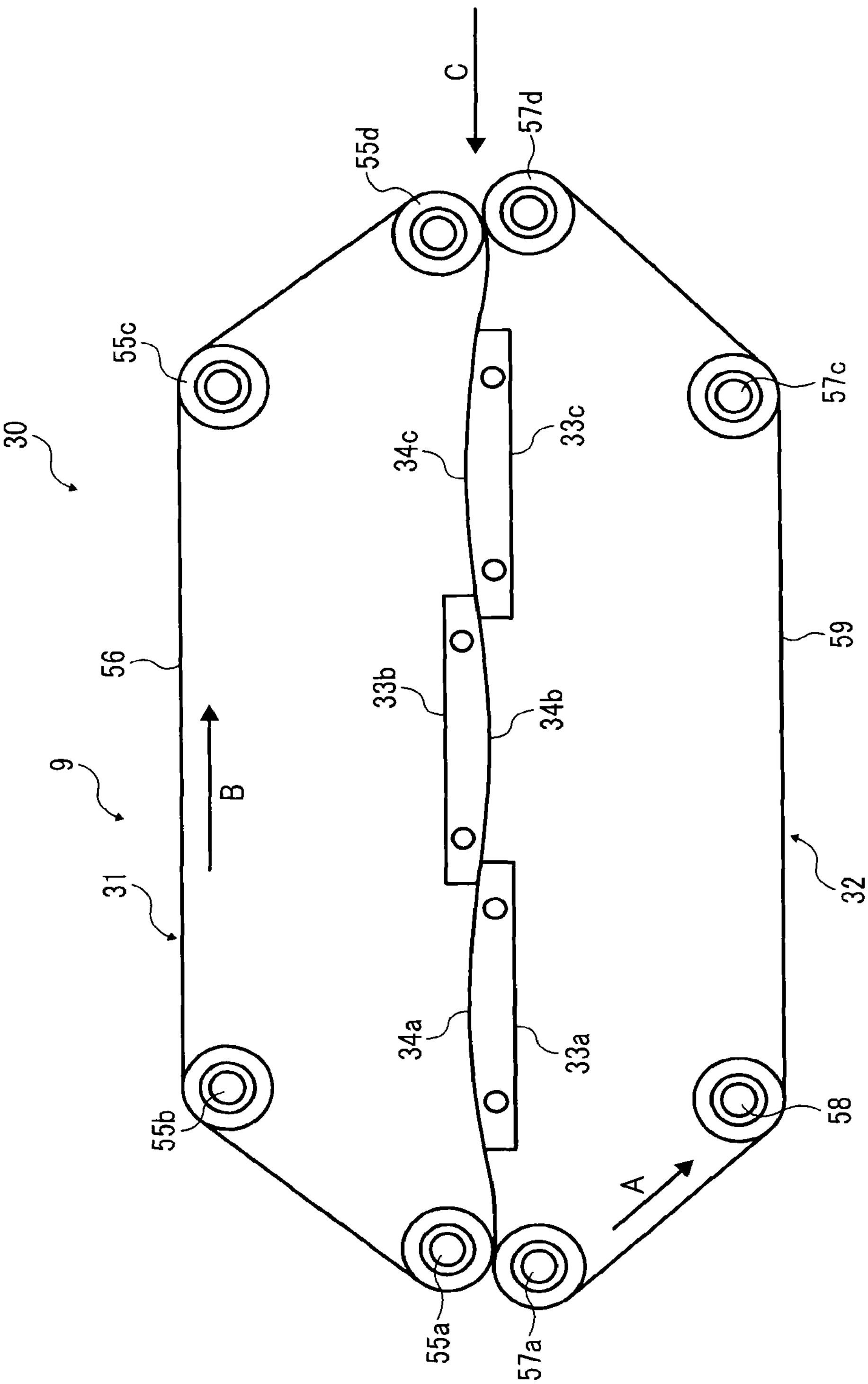

C
55d
57d
55c
57c
30
34c
33c
56
59
33b
34b
9
B
31
32
34a
33a
55b
58
A
55a
57a

FIG. 34

FIG. 35

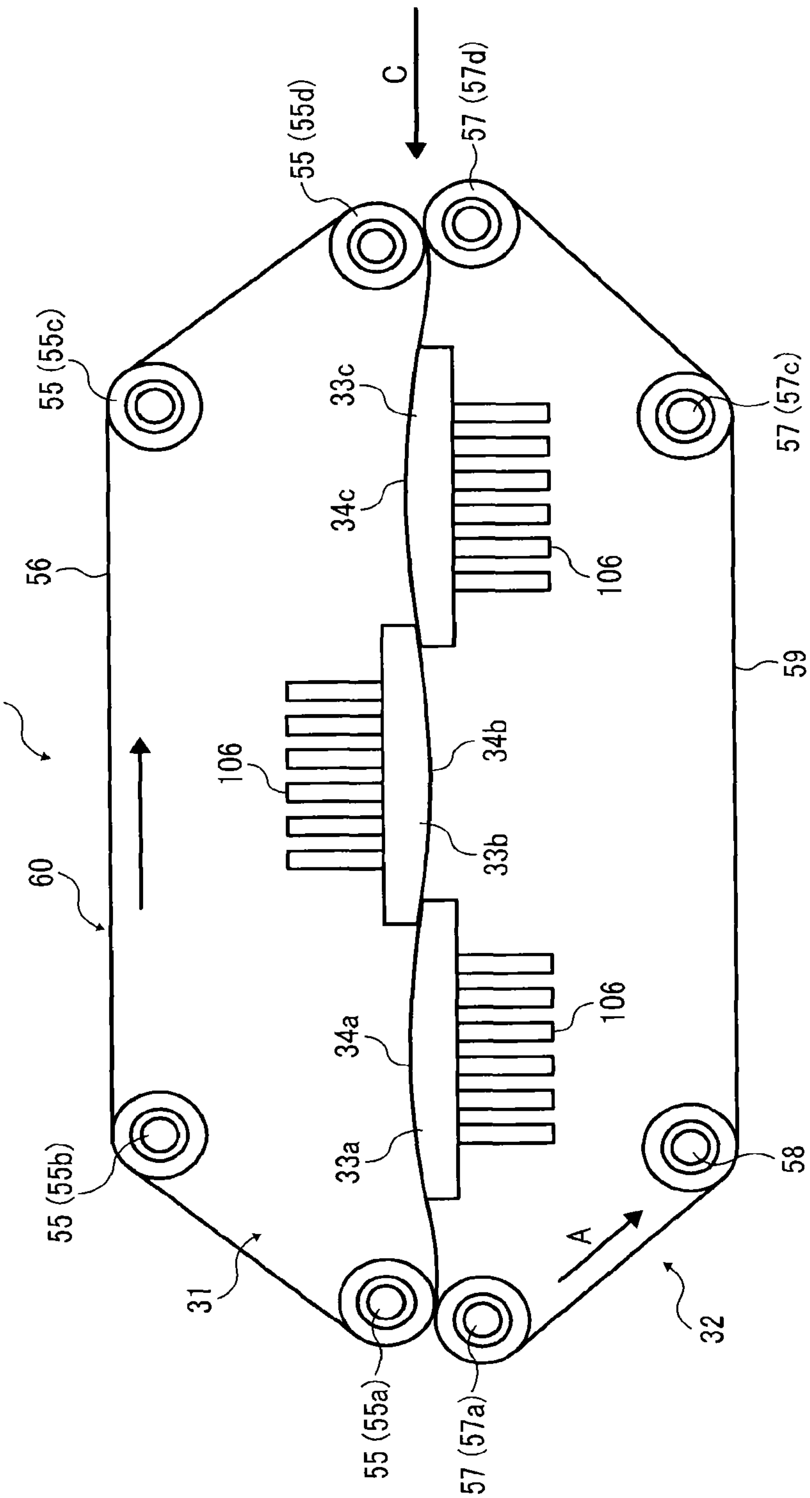
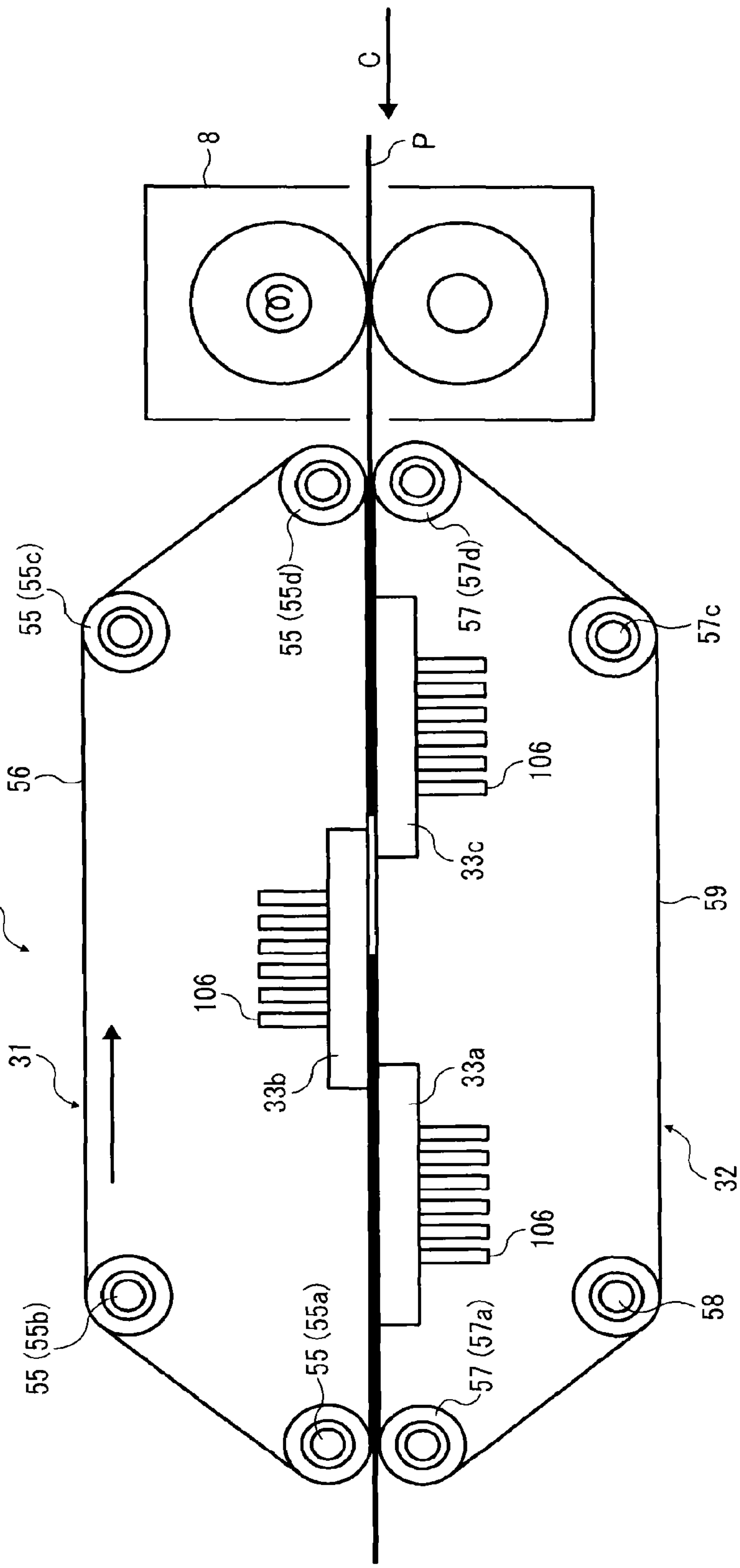

C
55 (55d)
57 (57d)
55 (55c)
33c
57 (57c)
34c
56
106
59
9
34b
106
33b
60
106
34a
33a
55 (55b)
58
A
31
32
55 (55a)
57 (57a)

FIG. 36


C
P
8
55 (55c)
55 (55d)
57 (57d)
57c
56
106
33c
9
59
106
31
33b
33a
32
106
55 (55b)
55 (55a)
57 (57a)
58

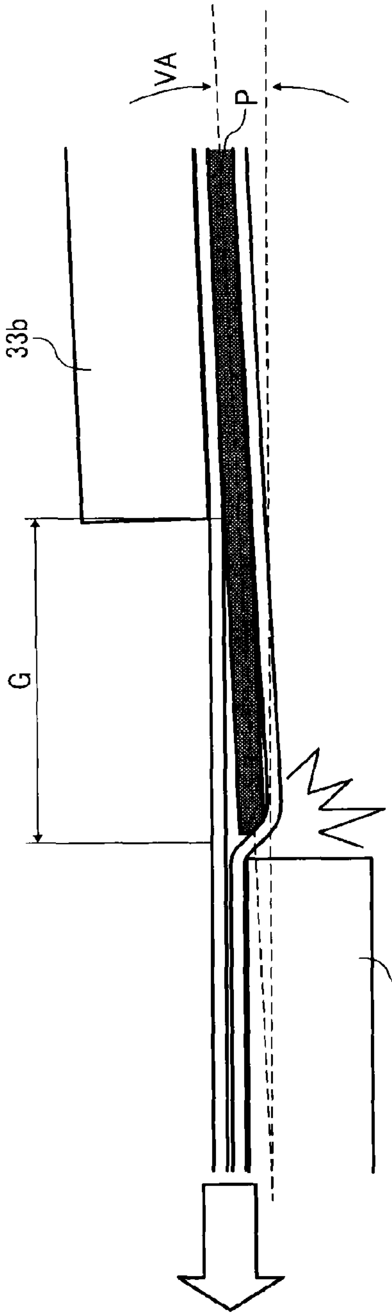



FIG. 37A

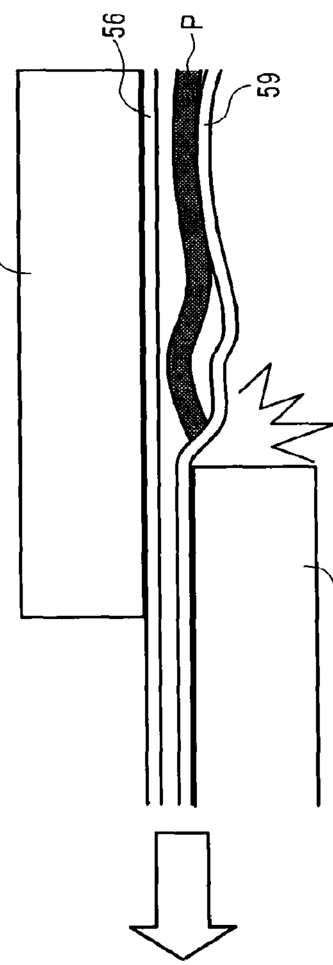



FIG. 37B

# COOLING DEVICE AND IMAGE FORMING APPARATUS INCLUDING SAME

## CROSS-REFERENCE TO RELATED APPLICATIONS

This patent application is a continuation of U.S. application Ser. No. 14/140,888, filed Dec. 26, 2013, which is based on and claims priority pursuant to 35 U.S.C. §119 to Japanese Patent Application Nos. 2012-285722, filed on Dec. 27, 2012, 2013-041649, filed on Mar. 4, 2013, and 2013-142510, filed on Jul. 8, 2013, in the Japan Patent Office. The entire disclosure of each of the above is incorporated by reference herein.

## BACKGROUND

1. Technical Field

Exemplary embodiments of this disclosure relate to a cooling device to cool a recording material (for example, a sheet-type recording material) and an image forming apparatus including the cooling device.

2. Description of the Related Art

Image forming apparatuses are used as, for example, copiers, printers, facsimile machines, and multi-functional devices having at least one of the foregoing capabilities. As one type of image forming apparatus, electrophotographic image forming apparatuses are known. Such an electrophotographic image forming apparatus may have a fixing device to fuse toner under heat and fix a toner image on a recording material (e.g., a sheet of paper). Such recording materials having toner images fixed thereon may be stacked on an output tray of the image forming apparatus.

In such a case, the recording materials having toner images are stacked one on another in heated state. As a result, toner is softened by heat retained in the stacked recording materials, and pressure due to the weight of the stacked recording materials may cause the recording materials to adhere to each other with softened toner. If the recording materials adhering to each other are forcefully separated, the fixed toner images might be damaged. Such an adhering state of the stacked recording materials is referred to as blocking. To suppress blocking, a cooling device may be employed to cool a recording material after a toner image is fixed on the recording material under heat.

For example, a cooling device is proposed to absorb heat from a recording material with cooling members while sandwiching and conveying the recording material by conveyance belts. Alternatively, it is known that cooling the recording material alternately from both faces rather than a single face allows more efficient cooling performance (e.g., JP-2012-098677-A1).

In addition, another cooling device is proposed that has enhanced capabilities of correcting curling of a recording material and cooling the recording material (e.g., JP-2009-161347-A1).

## BRIEF SUMMARY

In at least one exemplary embodiment of this disclosure, there is provided a recording-material cooling device including a first belt, a first cooling unit, and a second cooling unit. The first belt is disposed at a first face side of a recording material. The first cooling unit has a first heat absorbing surface to contact the first belt to absorb heat of the recording material. The second cooling unit has a second heat absorbing surface to directly or indirectly contact the recording material to absorb heat of the recording material. The second cooling unit is disposed at a second face side of the recording material. The first cooling unit and the second cooling unit are offset from each other in a transport direction of the recording material. Each of the first heat absorbing surface of the first cooling unit and the second heat absorbing surface of the second cooling unit has a shape in which an inner area protrudes beyond opposed ends in the transport direction of the recording material. The first heat absorbing surface and the second heat absorbing surface overlap each other in a direction crossing the transport direction of the recording material.



## BRIEF DESCRIPTION OF THE DRAWINGS

The aforementioned and other aspects, features, and advantages of the present disclosure would be better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

FIG. **1** is a schematic view of an image forming apparatus according to exemplary embodiments of this disclosure;

FIG. **2** is a side view of a cooling device disposed in the image forming apparatus illustrated in FIG. **1** according to an exemplary embodiment of this disclosure;

FIG. **3** is a perspective view of cooling members of the cooling device illustrated in FIG. **2**;

FIG. **4** is a side view of the cooling members of the cooling device illustrated in FIG. **2**;

FIG. **5** is a perspective view of the cooling device illustrated in FIG. **2** seen from a rear side thereof;

FIG. **6**A is a schematic view of conveyance belts and cooling members in contact state according to an exemplary embodiment of this disclosure;

FIG. **6**B is a schematic view of conveyance belts and cooling members according to a comparative example;

FIG. **7**A is an enlarged view of relative positions of belts and cooling members according to an exemplary embodiment of this disclosure;

FIG. **7**B is an enlarged view of guided directions of the belts illustrated in FIG. **7**A;

FIG. **8** is an enlarged view of belts and cooling members according to an exemplary embodiment of this disclosure;

FIGS. **9**A to **9**C are schematic views of displacement states of the belts when a recording material is transported to between the belts from a state illustrated in FIG. **8**;

FIG. **10** is an enlarged view of relative positions of belts and heat absorbing surfaces according to an exemplary embodiment of this disclosure;

FIG. **11** is an enlarged view of a belt and an end portion of a heat absorbing surface according to an exemplary embodiment of this disclosure;

FIG. **12** is a side view of cooling members of a cooling device according to an exemplary embodiment of this disclosure;

FIG. **13** is a side view of a cooling device according to an exemplary embodiment of this disclosure;

FIG. **14** is a side view of a cooling device according to an exemplary embodiment of this disclosure;

FIG. **15** is a side view of a cooling device according to an exemplary embodiment of this disclosure;

FIG. **16** is a perspective view of cooling members of the cooling device illustrated in FIG. **15**;

FIG. **17** is a side view of the cooling members of the cooling device illustrated in FIG. **15**;

FIG. **18** is a side view of a cooling device according to an exemplary embodiment of this disclosure;

FIG. **19** is a side view of a cooling device according to a comparative example of this disclosure;

FIG. **20** is a side view of a cooling device according to an exemplary embodiment of this disclosure;

FIG. **21** is an enlarged view of an example of relative positions of the rollers illustrated in FIG. **15**;

FIG. **22** is an enlarged view of a variation of relative positions of the rollers illustrated in FIG. **15**;

FIG. **23** is a side view of a cooling device according to an exemplary embodiment of this disclosure;

FIG. **24** is a side view of a cooling device according to an exemplary embodiment of this disclosure;

FIG. **25** is a side view of a cooling device according to an exemplary embodiment of this disclosure;

FIGS. **26**A and **26**B are enlarged views of a cooling device according to an exemplary embodiment of this disclosure;

FIG. **27**A is a schematic view of belts and cooling members according to an exemplary embodiment of this disclosure;

FIG. **27**B is a schematic view of belts and cooling members according to an exemplary embodiment of this disclosure;

FIG. **28** is a side view of a cooling device according to an exemplary embodiment of this disclosure;

FIGS. **29**A and **29**B are schematic views of transport of a recording material in an overlapping area of cooling members;

FIG. **30**A is a side view of a cooling device according to an exemplary embodiment of this disclosure;

FIG. **30**B is a side view of a cooling device according to an exemplary embodiment of this disclosure;

FIG. **31**A is a side view of a cooling device according to an exemplary embodiment of this disclosure;

FIG. **31**B is a side view of a cooling device according to an exemplary embodiment of this disclosure;

FIG. **32** is a schematic view of transport of a recording material in an overlapping area of cooling members;

FIG. **33** is a side view of a cooling device according to an exemplary embodiment of this disclosure;

FIG. **34** is a side view of a cooling device according to an exemplary embodiment of this disclosure;

FIG. **35** is a side view of a cooling device according to an exemplary embodiment of this disclosure;

FIG. **36** is a side view of a cooling device according to an exemplary embodiment of this disclosure;

FIG. **37**A is a schematic view of an example of a transport error in a comparative example of transport of a recording material; and

FIG. **37**B is a schematic view of an example of a transport error in a comparative example of transport of a recording material.

The accompanying drawings are intended to depict exemplary embodiments of the present disclosure and should not be interpreted to limit the scope thereof. The accompanying drawings are not to be considered as drawn to scale unless explicitly noted.

## DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

In describing embodiments illustrated in the drawings, specific terminology is employed for the sake of clarity. However, the disclosure of this patent specification is not intended to be limited to the specific terminology so selected and it is to be understood that each specific element includes all technical equivalents that operate in a similar manner and achieve similar results.

Although the exemplary embodiments are described with technical limitations with reference to the attached drawings, such description is not intended to limit the scope of the disclosure and all of the components or elements described in the exemplary embodiments of this disclosure are not necessarily indispensable.

Referring now to the drawings, exemplary embodiments of the present disclosure are described below. In the drawings for explaining the following exemplary embodiments, the same reference codes are allocated to elements (members or components) having the same function or shape and redundant descriptions thereof are omitted below.

FIG. **1** is a schematic view of an image forming apparatus according to exemplary embodiments of this disclosure.

The image forming apparatus illustrated in FIG. **1** includes a tandem-type image forming section in which four process units **1**Y, **1**C, **1**M, and **1**Bk serving as image forming units are arranged in tandem. The process units **1**Y, **1**C, **1**M, and **1**Bk are removably mountable relative to an apparatus body **200** of the image forming apparatus and have substantially the same configuration except for containing different color toners of yellow (Y), cyan (C), magenta (M), and black (Bk) corresponding to color separation components of a color image.

Specifically, each of the process units **1**Y, **1**C, **1**M, and **1**Bk includes, e.g., a photoreceptor **2**, a charging roller **3**, a developing device **4**, and a cleaning blade **5**. The photoreceptor **2** has, e.g., a drum shape and serves as a latent image carrier. The charging roller **3** serves as a charging device to charge a surface of the photoreceptor **2**. The developing device **4** forms a toner image on the surface of the photoreceptor **2**. The cleaning blade **5** serves as a cleaner to clean the surface of the photoreceptor **2**. In FIG. **1**, the photoreceptor **2**, the charging roller **3**, the developing device **4**, and the cleaning blade **5** of the process unit **1**Y for yellow are represented by the photoreceptor **2**Y, the charging roller **3**Y, the developing device **4**Y, and the cleaning blade **5**Y, respectively. Regarding the other process units **1**C, **1**M, and **1**Bk, color index are omitted for simplicity.

In FIG. **1**, above the process units **1**Y, **1**C, **1**M, and **1**Bk, an exposing device **6** is disposed to expose the surface of the photoreceptor **2**. The exposing device **6** includes, e.g., a light source, polygon mirrors, f-lenses, and reflection lenses to irradiate a laser beam onto the surface of the photoreceptor **2**.

A transfer device **7** is disposed below the process units **1**Y, **1**C, **1**M, and **1**Bk. The transfer device **7** includes an intermediate transfer belt **10** formed of an endless belt serving as a transfer body. The intermediate transfer belt **10** is wound around a plurality of rollers **21** to **24** serving as support members. One of the rollers **21** to **24** is rotated as a driving roller to circulate the intermediate (rotate) transfer belt **10** in a direction indicated by an arrow RD in FIG. **1**.

Four primary transfer rollers **11** serving as primary transfer devices are disposed at positions at which the primary transfer rollers **11** oppose the respective photoreceptors **2**. At the respective positions, the primary transfer rollers **11** are pressed against an inner circumferential surface of the intermediate transfer belt **10**. Thus, primary transfer nips are formed at positions at which the photoreceptors **2** contact pressed portions of the intermediate transfer belt **10**. Each of the primary transfer rollers **11** is connected to a power source, and a predetermined direct current (DC) voltage and/or an alternating current (AC) voltage are supplied to the primary transfer rollers **11**.

A secondary transfer roller **12** serving as a second transfer device is disposed at a position at which the secondary transfer roller **12** opposes the roller **24**, which is one of the rollers around which the intermediate transfer belt **10** is wound. The secondary transfer roller **12** is pressed against an outer circumferential surface of the intermediate transfer belt **10**. Thus, a secondary transfer nip is formed at a position at which the secondary transfer roller **12** and the intermediate transfer belt **10** contact each other. Like the primary transfer rollers **11**, the secondary transfer roller **12** is connected to a power source, and a predetermined direct current (DC) voltage and/or an alternating current (AC) voltage are supplied to the secondary transfer roller **12**.

Below the apparatus body **200** is a plurality of feed trays **13** to store sheet-type recording materials P, such as a sheet of paper or overhead projector (OHP) sheet. Each feed tray **13** is provided with a feed roller **14** to feed the recording materials P stored. An output tray **20** is mounted on an outer surface of the apparatus body **200** at the left side in FIG. **1** to stack recording materials P discharged to an outside of the apparatus body **200**.

The apparatus body **200** includes a transport path R to transport a recording material P from the feed trays **13** to the output tray **20** through the secondary transfer nip. On the transport path R, registration rollers **15** are disposed upstream from the secondary transfer roller **12** in a transport direction of a recording material (hereinafter, recording-material transport direction). A fixing device **8**, a cooling device **9**, and paired output rollers **16** are disposed in turn at positions downstream from the secondary transfer roller **12** in the recording-material transport direction. The fixing device **8** includes a fixing roller **17** and a pressing roller **18**. The fixing roller serves as a fixing member including an internal heater. The pressing roller **18** serves as a pressing member to press the fixing roller **17**. A fixing nip is formed at a position at which the fixing roller **17** and the pressing roller **18** contact each other.

Next, a basic operation of the image forming apparatus is described with reference to FIG. **1**.

When imaging operation is started, the photoreceptor **2** of each of the process units **1**Y, **1**C, **1**M, and **1**Bk is rotated counterclockwise in FIG. **1**, and the charging roller **3** uniformly charges the surface of the photoreceptor **2** with a predetermined polarity. Based on image information of a document read by a reading device, the exposing device **6** irradiates laser light onto the charged surface of the photoreceptor **2** to form an electrostatic latent image on the surface of the photoreceptor **2**. At this time, image information exposed to each photoreceptor **2** is single-color image information obtained by separating a desired full-color image into single-color information on yellow, cyan, magenta, and black. Each developing device **4** supplies toner onto the electrostatic latent image formed on the photoreceptor **2**, thus making the electrostatic latent images a visible image as a toner image.

One of the rollers **21** to **24** around which the intermediate transfer belt **10** is wound is driven for rotation to circulate the intermediate transfer belt **10** in the direction RD in FIG. **1**. A voltage having a polarity opposite a charged polarity of toner and subjected to constant voltage or current control is supplied to each of the primary transfer rollers **11**. As a result, a transfer electric field is formed at the primary transfer nip between each primary transfer roller **11** and the opposing photoreceptor **2**. Toner images of respective colors on the photoreceptors **2** are transferred one on another onto the intermediate transfer belt **10** by the transfer electric fields formed at the primary transfer nips. Thus, the intermediate transfer belt **10** bears a full-color toner image on the surface of the intermediate transfer belt **10**. Residual toner remaining on each photoreceptor **2** without being transferred onto the intermediate transfer belt **10** is removed with the cleaning blade **5**.

With rotation of the feed roller **14**, a recording material P is fed from the corresponding feed tray **13**. The recording material P is further sent to the secondary transfer nip between the secondary transfer roller **12** and the intermediate transfer belt **10** by the registration rollers **15** so as to synchronize with the full-color toner image on the intermediate transfer belt **10**. At this time, a transfer voltage of the polarity opposite the charged polarity of toner of the toner image on the intermediate transfer belt **10** is supplied to the secondary transfer roller **12**. As a result, a transfer electric field is formed at the secondary transfer nip. By the transfer electric field formed at the secondary transfer nip, the toner image on the intermediate transfer belt **10** is collectively transferred onto the recording material P. Then, the recording material P is sent into the fixing device **8**, and the fixing roller **17** and the pressing roller **18** apply heat and pressure to fix the toner image on the recording material P. After the recording material P is cooled with the cooling device **9**, the paired output rollers **16** output the recording material P onto the output tray **20**.

The above description relates to image forming operation for forming a full color image on a recording material. In other image forming operation, a single color image can be formed by any one of the process units **1**Y, **1**M, **1**C, and **1**Bk, or a composite color image of two or three colors can be formed by two or three of the process units **1**Y, **1**M, **1**C, and **1**Bk.

As illustrated in FIG. **2**, the cooling device **9** has a cooling member **33** to cool a sheet-type recording material P conveyed by traveling of belts of a belt transport unit **30**. The belt transport unit **30** includes a first transport assembly **31** and a second transport assembly **32**. The first transport assembly **31** is disposed at one face side (front face side or upper face side) of the sheet-type recording material P. The second transport assembly **32** is disposed at the other face side (back face side or lower face side) of the sheet-type recording material P. The belt transport unit **30** also includes a pair of the cooling members **33***a* and **33***b*. The cooling member **33***a* serving as a first cooling unit is disposed at one face side (front face side or upper face side) of the sheet-type recording material P. The cooling member **33***b* serving as a second cooling unit is disposed at the other face side (back face side or lower face side) of the sheet-type recording material P.

As illustrated in FIGS. **3** and **4**, each of the cooling members **33** includes a cooling body **35** of a rectangular flat-plate shape and lateral edges **36***a* and **36***b* disposed at lateral faces of the cooling body **35**. The lateral edges **36***a* and **36***b* of the cooling member **33***a* have contact portions **37***a* and **37***b*, respectively. The contact portions **37***a* and **37***b* protrude toward an upstream side beyond an upstream edge of the cooling body **35** in a recording-material transport direction indicated by an arrow C in FIG. **2**. The lateral edges **36***a* and **36***b* of the cooling member **33***b* include contact portions **38***a* protruding toward a downstream side beyond a downstream edge of the cooling body **35** in the recording-material transport direction C.

In such a case, in a state in which the contact portions **37***a* and **37***b* of the cooling member **33***a* are in contact with the contact portions **38***a*, respectively, of the cooling member

**33***b*, the contact portions **37***a* and **37***b* overlap the contact portions **38***a*, so that the cooling member **33***a* and the cooling member **33***b* are offset from each other in the transport direction of the sheet-type recording material. The place of overlap is designated as S, or S**1**. The cooling body **35** of the cooling member **33***a* has, as a lower surface, a heat absorbing surface **34***a* of an arc surface shape slightly protruding downward. The cooling body **35** of the cooling member **33***b* has a heat absorbing surface **34***b* of an arc surface shape slightly protruding upward.

Each of the cooling members **33***a* and **33***b* includes a cooling liquid channel through which cooling liquid flows. The contact portions **38***a* disposed at a rear side of the cooling device have openings **40***a*, **40***b*, **41***a*, and **41***b* of circulation channels.

In other words, as illustrated in FIG. **5**, the cooling device **9** has a cooling-liquid circuit **44**. The cooling-liquid circuit **44** includes a heat receiving part **45** to receive heat from a recording material P serving as a heat generating part, a heat dissipating part **46** to radiate heat of the heat receiving part **45**, and a circulation channel **47** to circulate cooling liquid through the heat receiving part **45** and the heat dissipating part **46**. The circulation channel **47** includes a pump **48** to circulate cooling liquid and a liquid tank **49** to store cooling liquid, thus causing the cooling members **33***a* and **33***b* to function as the heat receiving part **45**. The heat dissipating part **46** includes, e.g., a radiator. The cooling liquid is, for example, magnetic fluid. The magnetic fluid includes, e.g., water, hydrocarbon oil, or fluorine oil as medium and ferromagnetic ultrafine particles, such as high concentration of magnetite, dispersed in stable state in the medium. Additionally, surface-active agent is chemically attached to surfaces of the ferromagnetic ultrafine particles.

The circulation channel **47** includes pipes **50** to **54**. The pipe **50** connects the opening **40***a* of the cooling member **33***a* to the heat dissipating part **46** (e.g., radiator). The pipe **51** connects the opening **40***b* of the cooling member **33***a* to the opening **41***a* of the cooling member **33***b*. The pipe **52** connects the opening **41***b* of the cooling member **33***b* to the liquid tank **49**. The pipe **53** connects the liquid tank **49** to the pump **48**. The pipe **54** connects the pump **48** to the heat dissipating part **46**.

The first transport assembly **31** includes a plurality of rollers **55** and a belt (conveyance belt) **56** wound around the plurality of rollers **55**. The second transport assembly **32** includes a plurality of rollers **57**, a single roller (driving roller) **58**, and a belt (conveyance belt) **59** wound around the plurality of rollers **57** and the driving roller **58**.

Accordingly, a recording material P is sandwiched and conveyed by the belt **56** of the first transport assembly **31** and the belt **59** of the second transport assembly **32**. In other words, as illustrated in FIG. **2**, the belt **59** is traveled in a direction indicated by an arrow A by a driving unit. With travel of the belt **59**, the belt **56** of the first transport assembly **31** is traveled in a direction indicated by an arrow B via the recording material P sandwiched between the belts **56** and **59**. Thus, the recording material P is conveyed from an upstream side to a downstream side in the transport direction indicated by the arrow C in FIG. **2**.

For the first transport assembly **31** and the second transport assembly **32**, as illustrated in FIGS. **3** and **4**, the contact portions **37***a* and **37***b* of the cooling member **33***a* are in contact with the contact portions **38***a*, respectively, of the cooling member **33***b*. In such a state, as illustrated in, e.g., FIG. **2**, the cooling member **33***a* and the cooling member **33***b* are offset from each other in the transport direction C of the sheet-type recording material. Thus, the contact portions



**37***a* and **37***b* and the contact portions **38***a* position the recording material P with respect to a thickness direction of the recording material P (hereinafter, the recording-material thickness direction).

With respect to the recording-material transport direction, the cooling member **33***a* and the cooling member **33***b* are positioned by side plates.

As described above, the cooling device **9** has a first positioning unit S**1**. The first positioning unit S**1** defines relative positions of the first transport assembly **31** and the second transport assembly **32** with respect to the recording-material thickness direction. As described above, the first positioning unit S**1** in the recording-material thickness direction performs positioning with the contact portions **37***a* and **37***b* of the cooling member **33***a* and the contact portions **38***a* of the cooling member **33***b*. It is to be noted that, the configuration of the first positioning unit S**1** is not limited to the above-described configuration and, for example, the contact portions **37***a*, **37***b*, and **38***a*, may be integrally molded with the apparatus body **200**.

Next, operation of the cooling device having the above-described configuration is described below. When the recording material P is sandwiched and conveyed by the belts **56** and **59**, as illustrated in, e.g., FIG. **2**, the first transport assembly **31** and the second transport assembly **32** are placed adjacent to each other. In a state illustrated in FIG. **2**, if the driving roller **58** of the second transport assembly **32** is rotated, as described above, the belts **56** and **59** travel in the directions indicated by the arrows A and B, respectively, to transport the recording material P in the transport direction indicated by the arrow C. In such a state, cooling liquid is circulated in the cooling-liquid circuit **44**. In other words, the pump **48** is activated to flow the cooling liquid through the cooling liquid channels of the cooling members **33***a* and **33***b*.

At this time, an inner surface of the belt **56** of the first transport assembly **31** slides over the heat absorbing surface **34***a* of the cooling member **33***a*, and an inner surface of the belt **59** of the second transport assembly **32** slides over the heat absorbing surface **34***b* of the cooling member **33***b*. From a front surface (upper surface) side of the recording material P, the cooling member **33***a* absorbs heat of the recording material P via the belt **56**. From a back surface (lower surface) side of the recording material P, the cooling member **33***b* absorbs heat of the recording material P via the belt **59**. In such a case, an amount of heat absorbed by the cooling members **33***a* and **33***b* is transported to the outside by the cooling liquid, thus maintaining the cooling members **33***a* and **33***b* at relatively low temperature.

In other words, by driving the pump **48**, the cooling liquid is circulated through the cooling-liquid circuit **44**. The cooling liquid flows through the cooling-liquid channels of the cooling members **33***a* and **33***b*, absorbs heat of the cooling members **33***a* and **33***b*, and turns into a relatively high temperature. The cooling liquid at high temperature passes through the heat receiving part **45** (e.g., radiator), and heat of the cooling liquid is radiated to outside air, thus reducing the temperature of the cooling liquid. The cooling liquid at relatively low temperature flows through the cooling-liquid channels again, and the cooling members **33***a* and **33***b* act as the heat dissipating part **46**. By repeating the above-described cycle, the recording material P is cooled from both sides thereof.

With such a configuration, the cooling device **9** cools recording materials P to prevent the recording materials P from being stacked on the output tray **20** at high temperature. As a result, the cooling device **9** effectively prevents blocking, thus allowing the recording materials P to be stacked on the output tray **20** without adhering to each other.

FIG. **6**A is a schematic view of conveyance belts **56** and **59** and cooling members **33***a* and **33***b* in a contact state according to an exemplary embodiment of this disclosure. FIG. **6**B is a schematic view of conveyance belts **56** and **59** and cooling members **33***a* and **33***b* according to a comparative example.

In FIG. **6**A, heat absorbing surfaces **34***a* and **34***b* of the cooling members **33***a* and **33***b* are arc surfaces (of a shape in which a middle portion protrudes beyond end portions thereof). Each of the heat absorbing surfaces **34***a* and **34***b* is formed along the transport path R. Additionally, the cooling members **33***a* and **33***b* are offset from each other in both the thickness direction and the transport direction of the recording material P. By contrast, for example, if flat-shaped cooling members are employed, upstream and downstream end portions of the cooling members in a belt conveyance direction rub against each other, thus imposing burden to the belts. Hence, in exemplary embodiments of the disclosure, the heat absorbing surfaces **34***a* and **34***b* are formed as arc surfaces, thus reducing the burden to the belts **56** and **59**.

In the comparative example illustrated in FIG. **6**B, the cooling members **33***a* and **33***b* do not overlap each other in the recording-material thickness direction. In such a case, since the absorbing surface **34***a* of the cooling member **33***a* and the heat absorbing surface **34***b* of the cooling member **33***b* are arc surfaces, the belts **56** and **59** do not contact the cooling members **33***a* and **33***b* at portions H**2**, H**3**, and H**4** in FIG. **6**B. Such a configuration may not effectively absorb heat of the recording material P.

By contrast, in the configuration illustrated in FIG. **6**A, the cooling members **33***a* and **33***b* overlap each other in the recording-material thickness direction. The heat absorbing surface **34***b* is disposed upper than upper surfaces of the rollers **57***a* and **57***d*. The heat absorbing surface **34***a* is disposed lower than lower surfaces of the rollers **55***a* and **55***d*. As a result, the belt **59** is raised from an outer circumference of the roller **57***d* toward the heat absorbing surface **34***b*, bent upward and downward along the heat absorbing surface **34***b*, bent downward and upward along the heat absorbing surface **34***a*, and bent around an outer circumference of the roller **57***a*. On the other hand, the belt **56** is raised from an outer circumference of the roller **55***d* toward the heat absorbing surface **34***b*, bent upward and downward along the heat absorbing surface **34***b*, bent downward and upward along the heat absorbing surface **34***a*, and bent around an outer circumference of the roller **55***a*.

Such a configuration increases the contact areas in which the belts **56** and **59** contact the heat absorbing surfaces **34***a* and **34***b*, thus more effectively absorbing heat of the recording material P than the configuration illustrated in FIG. **6**B.

FIGS. **7**A and **7**B are schematic views of belts **56** and **59** and cooling members **33***a* and **33***b* according to an exemplary embodiment of this disclosure.

In FIGS. **7**A and **7**B, as illustrated in FIG. **6**A, relative positions between the belts **56** and **59** and the cooling members **34***a* and **34***b* are shown as enlarged views. In other words, FIG. **7**A is an enlarged view of relative positions of the belts **56** and **59** and end portions of the heat absorbing surfaces **34***a* and **34***b*. FIG. **7**B is an enlarged view of guided directions of the belts **56** and **59** illustrated in FIG. **7**A. For example, for the configuration illustrated in FIG. **6**A in which the cooling members **33***a* and **33***b* are arranged to overlap each other in the recording-material thickness direction, the belts **56** and **59** preferably contact edges of the cooling members **33***a* and **33***b*. However, if the belts **56** and **59** wind around the edges of the cooling members **33***a* and **33***b*, large pressure might be applied to the belts **56** and **59** or a sheet-shaped recording material P, thus accelerating deterioration of the belts **56** and **59**.

Hence, as illustrated in FIG. **7**B, a heat absorbing surface **34***a* and a heat absorbing surface **34***b* are arranged so that a tangent line (first tangent line) **101***a* to an edge **100***a* of the heat absorbing surface **34***a* (i.e., first tangent line to an edge of a contact surface of the first cooling member (cooling member **33***a*) to contact the belt **56**) is in parallel to a tangent line **101***b* to an edge **100***b* of the heat absorbing surface **34***b* (i.e., second tangent line to an edge of a contact surface of the second cooling member (cooling member **33***b*) to contact the belt **59**),i.e., the direction of the tangent line **101***a* is the same as the direction of the tangent line **101***b*. As a result, the belts **56** and **59** contact the edges **100***a* and **100***b* of the heat absorbing surfaces **34***a* and **34***b*, respectively, and the degree of concentration of pressure is relatively low on the edges **100***a* and **100***b* of the heat absorbing surfaces **34***a* and **34***b*. Such a configuration increases the distances (areas) at which the belts **56** and **59** contact the heat absorbing surfaces **34***a* and **34***b*, respectively, thus reducing the burden to the belts **56** and **59** while maintaining high cooling efficiency.

FIG. **8** is an enlarged view of belts **56** and **59** and cooling members **34***a* and **34***b* according to an exemplary embodiment of this disclosure.

The arrangement of FIG. **8** differs from the arrangement of FIGS. **7**A and **7**B in that edges **100***a* and **100***b* of heat absorbing surfaces **34***a* and **34***b* are separated from the belts **56** and **59**. The arrangement of FIG. **8** is the same as the arrangement of FIGS. **7**A and **7**B in the other points, and therefore, the same reference codes are allocated to the same components, and redundant descriptions thereof are omitted (which is the same in the following examples).

For the arrangement of FIG. **8**, the belts **56** and **59** contact end portions of the heat absorbing surfaces **34***a* and **34***b*, respectively, at inner positions within the widths of the heat absorbing surfaces **34***a* and **34***b*, unlike the edges **100***a* and **100***b* illustrated in FIGS. **7**A and **7**B. Like the arrangement of FIGS. **7**A and **7**B, tangent lines to the edge portions are the same between the belts **56** and **59**. The tangent lines are separated from the edges **100***a* and **100***b* of the heat absorbing surfaces **34***a* and **34***b*. Thus, the belts **56** and **59** are not in contact with the edges **100***a* and **100***b* of the heat absorbing surface **34***a* and **34***b*, respectively.

FIGS. **9**A to **9**C are schematic views of displacement states of the belts **56** and **59** when a recording material P is transported to between the belts **56** and **59** from a state illustrated in FIG. **8**.

When the recording material P is moved toward the heat absorbing surface **34***b* from the state of FIG. **8** before a recording material P is transported, as illustrated in FIG. **9**A, the belts **56** and **59** are spread by the recording material P. When the recording material P approaches the edge **100***b* of the heat absorbing surface **34***b*, as illustrated in FIG. **9**B, the belt **59** contacts the edge **100***b* or is further spread so as to form a slight clearance. When the recording material P is further moved toward the heat absorbing surface **34***a*, as illustrated in FIG. **9**C, the belt **56** contacts the edge **100***a* or is further spread so as to form a slight clearance. Thus, the recording material P is transported.

For such a configuration, when the recording material P do not pass, the belts **56** and **59** do not contact the edges **100***a* and **100***b* and their nearby portions of the cooling members **33***a* and **33***b*. By contrast, when the recording material P passes between the belts **56** and **59**, the contact areas between the belts **56** and **59** and the heat absorbing surfaces **34**_a_ and **34**_b_, respectively, are increased by the thickness of the recording material. Thus, the burden to the belts **56** and **59** can be reduced. When the recording material passes, the contact areas between the belts **56** and **59** and the heat absorbing surfaces **34**_a_ and **34**_b_, respectively, are increased, thus maintaining high cooling efficiency.

FIG. **10** is an enlarged view of relative positions between cooling members **33**_a_ and **33**_b_ and belts **56** and **59** in a variation of the above-described exemplary embodiment illustrated in FIG. **8**.

The thicker a recording material P, the greater the amount of heat accumulated in the recording material P. Hence, in the variation illustrated in FIG. **10**, when the recording material P is conveyed, the contact area between the belt **56** (or **59**) and a heat absorbing surface **34**_a_ (or **34**_b_) has a maximum value. Accordingly, the belts **56** and **59** are arranged so that a tangent line to an end portion of the heat absorbing surface **34**_b_ is placed away from a tangent line to an end portion of the heat absorbing surface **34**_a_ by a distance L. Here, a relation of $L=2d+D$ is satisfied, where d represents the thickness of each of the belts **56** and **59** and D represents the thickness of a thickest one of usable recording materials P.

For such a configuration, when a recording material P does not pass between the belts **56** and **59**, the belts **56** and **59** do not contact the edges **100**_a_ and **100**_b_ and their nearby portions of the heat absorbing surfaces **34**_a_ and **34**_b_, respectively. By contrast, when the thickest recording material P passes between the heat absorbing surfaces **34**_a_ and **34**_b_, the belts **56** and **59** contact the edges **100**_a_ and **100**_b_ and/or their nearby portions by the thickness of the recording material P. Such a configuration reduces the burden to the belts **56** and **59**. As described above, when the thickest recording material P passes, the belts **56** and **59** contact the edges **100**_a_ and **100**_b_ and/or their nearby portions of the heat absorbing surfaces **34**_a_ and **34**_b_, thus maintaining high cooling efficiency.

In the above-described exemplary embodiments of FIGS. **7**A to **7**C, FIG. **8**, and FIG. **10**, in a state in which the recording material P is not transported, the edges **100**_a_ and **100**_b_ are separated from the belts **56** and **59** to reduce burden to the belts **56** and **59**. In a configuration illustrated in FIG. **11**, an edge surface **34**_a_**2** of a cooling member **33**_a_ has a shape different from that of any of the above-described embodiments to reduce burden to a belt **56**.

FIG. **11** is an enlarged view of the belt **56** and an end portion of the heat absorbing surface **34**_a_ according to an exemplary embodiment.

A heat absorbing surface **34**_b_ in this exemplary embodiment has a similar configuration, and therefore redundant descriptions thereof are omitted below. In this exemplary embodiment, the cooling member **33**_a_ is different from any of the above-described embodiments in shapes of the heat absorbing surface **34**_a_ and the end portion thereof. For example, as illustrated in FIG. **11**, a first surface **34**_a_**1** serving as a contact portion to contact the belt **56** has an angle $\theta 1$ with respect to an imaginary center O1 and the edge surface **34**_a_**2** not contacting the belt **56** has an angle $\theta 2$ ($\theta 1 \neq \theta 2$) with respect to an imaginary center O2. In such a case, a tangent line drawn (from the first surface **34**_a_**1** side) to a changing point CP between the first surface **34**_a_**1** and the edge surface **34**_a_**2** as the end portion of the heat absorbing surface **34**_a_ has the same direction as a tangent line to an end portion of the heat absorbing surface **34**_b_. Such a configuration reduces burden to the belt **56** with a simple structure. It is to be noted that, the configuration of this exemplary embodiment may be employed in combination of at least one of the above-described exemplary embodiments of FIGS. **7**A to **7**C, FIG. **8**, and FIG. **10**.

For an exemplary embodiment illustrated in FIG. **12**, elastic pressing members (e.g., springs) **110** and **111** press cooling members **33**_a_ and **33**_b_ toward belts **56** and **59**, respectively. FIG. **12** is a schematic view of a cooling device **9** seen from a rear side of an image forming apparatus. In FIG. **12**, a recording material P is transported from the left side to the right side.

In this exemplary embodiment, the cooling device **9** includes a first moving unit to move a first cooling unit in a direction crossing a transport direction of the recording material and a second moving unit to move a second cooling unit in a direction crossing the transport direction of the recording material. In such a case, the first moving unit includes the cooling member **33**_a_ serving as the first cooling unit, and the second moving unit includes the cooling member **33**_b_ serving as the second cooling unit. In other words, the cooling members **33**_a_ and **33**_b_ have guide portions to move up and down in a direction perpendicular to surfaces of belts **56** and **59** and restrict the rotation thereof. When the recording material P is not transported, the belts **56** and **59** and the heat absorbing surfaces **34**_a_ and **34**_b_ are placed in a state illustrated in FIG. **7**A. When the recording material P is transported to the heat absorbing surfaces **34**_a_ and **34**_b_, the cooling member **33**_b_ moves downward and the cooling member **33**_a_ moves upward. The total movement amount of the cooling members **33**_a_ and **33**_b_ is adjusted to be equal to the distance L illustrated in FIG. **10**. Such a configuration reduces burden imposed from the end portions of the heat absorbing surfaces **34**_a_ and **34**_b_ to the belts **56** and **59**.

Exemplary embodiments of this disclosure are not limited to the configuration in which the belts are disposed so as to sandwich the transport path of a recording material in the recording-material thickness direction. In some embodiments, a cooling device includes a belt at only one side of the transport path in the recording-material thickness direction. FIG. **13** is a schematic view of a cooling device having such a configuration according to an exemplary embodiment of this disclosure. In this exemplary embodiment, as illustrated in FIG. **13**, a guide roller assembly **140** is provided instead of the above-described lower conveyance unit **32**. In other words, in such a case as well, the cooling device **9** includes two cooling members **33**_a_ and **33**_b_. Rollers **141**_c_ and **141**_d_ are disposed below the cooling member **33**_b_. A guide plate **142**_c_ is disposed between the rollers **141**_c_ and **141**_d_. A guide plate **142**_d_ is disposed upstream from the roller **141**_d_.

The guide plates **142**_c_ and **142**_d_ and the rollers **141**_c_ and **141**_d_ form the guide roller assembly **140**.

In such a case, when a driving roller **58** is rotated, a belt **56** travels. The recording material P is guided by the guide plates **142**_c_ and **142**_d_ of the guide roller assembly **140** and the rollers **141**_c_ and **141**_d_, and passes through the cooling device.

An upper surface of the recording material P contacts and is cooled by a heat absorbing surface **34**_b_, i.e., a lower surface of the cooling member **33**_b_ via the belt **56**. Then, a lower surface of the recording material P directly contacts and is cooled by a heat absorbing surface **34**_a_, i.e., an upper surface of the cooling member **33**_a_. The relative positions between the belt **56** and the cooling members **33**_a_ and **33**_b_ described in at least one of the above-described exemplary embodiments are also applicable in this exemplary embodiment.

For the cooling device **9** according to this exemplary embodiment, the guide roller assembly **140** serves as the lower transport unit (corresponding to the lower transport assembly **32**) and thus allows downsizing of the image forming apparatus.

Exemplary embodiments of this disclosure are not limited to the cooling device employing the cooling-liquid circuit **44** in FIG. **5**. For example, as illustrated in FIG. **14**, a cooling device **9** according to an exemplary embodiment includes a radiation facilitating part **106**. As the radiation facilitating part **106**, for example, an air-cooling heat sink having multiple fins is employed. In such a case, the relative positions between the heat absorbing surfaces **34***a* and **34***b* and the belts **56** and **59** described in any of the above-described exemplary embodiments are also applicable in this exemplary embodiment.

As described above, use of the air-cooling heat sink obviates use of the cooling-liquid circuit **44**, thus allowing downsizing and cost reduction of the apparatus.

FIG. **15** is a side view of a cooling device **9** according to an exemplary embodiment of this disclosure.

As illustrated in FIG. **15**, the cooling device **9** includes a belt transport unit **30** and cooling members **33** (**33***a* and **33***b*) to cool a recording material P transported by traveling of belts **56** and **59** of the belt transport unit **30**. The belt transport unit **30** includes a first transport assembly **31** and a second transport assembly **32**. The first transport assembly **31** is disposed at one face side (front face side or upper face side) of the recording material P. The second transport assembly **32** is disposed at the other face side (back face side or lower face side) of the recording material P. The first transport assembly **31** has the belt **56** serving as belt member rotatably held by and stretched over a plurality of rollers **55***a* to **55***d*. The second transport assembly **32** has the belt **59** serving as belt member rotatably held by and stretched over a plurality of rollers **57***a*, **57***c*, **57***d*, and **58**. The belt transport unit **30** also includes a pair of cooling members **33***a* and **33***b* disposed in contact with inner circumferential surfaces of the belts **56** and **59**, respectively. The cooling member **33***a* is disposed at one face side (front face side or upper face side) of the recording material P. The cooling member **33***b* is disposed at the other face side (back face side or lower face side) of the recording material P.

As illustrated in FIGS. **16** and **17**, each of the cooling members **33***a* and **33***b* includes a cooling body **35** of a rectangular flat-plate shape and lateral edges **36***a* and **36***b* disposed at lateral faces of the cooling body **35**. The cooling member **33***a* is not in contact with the cooling member **33***b* and is disposed upper than the cooling member **33***b*. The cooling body of the cooling member **33***a* has a heat absorbing surface **34***a* as a lower surface thereof, and the heat absorbing surface **34***a* has an arc surface shape slightly protruding downward. The cooling body **35** of the cooling member **33***b* has a heat absorbing surface **34***b* of an arc surface shape slightly protruding upward.

Each of the cooling members **33***a* and **33***b* includes a cooling liquid channel through which cooling liquid flows. At a side corresponding to a rear side of an image forming apparatus, the cooling member **33***a* has openings **40***a*, **40***b*, **41***a*, and **41***b* for circulation channels connected to the cooling liquid channel.

Next, the belt transport unit **30** is further described below.

As illustrated in FIG. **15**, with respect to the recording-material transport direction, the first cooling member **33***a* inside the belt **56** of the first transport assembly **31** has a length shorter than the cooling member **33***b* inside the belt **59** of the second transport assembly **32**. As a result, a contact area of the first cooling member **33***a* against an inner circumferential surface of the belt **56** is smaller than a contact area of the cooling member **33***b* against an inner circumferential surface of the belt **59**. Thus, the first transport assembly **31** has a belt rotation resistance smaller than a belt rotation resistance of the second transport assembly **32**.

In addition, as described below, the cooling members **33***a* and **33***b* are arranged so that the heat absorbing surfaces **34***a* and **34***b* of an arc surface shape partially overlap each other in an upward and downward direction. In other words, an upper end surface of the heat absorbing surface **34***b* of the cooling member **33***b* disposed at a lower side is disposed upper than a lower end surface of the heat absorbing surface **34***a* of the first cooling member **33***a* disposed at an upper side. The belt **56** is stretched so as to contact the heat absorbing surface **34***a* along the arc surface shape of the heat absorbing surface **34***a*, and the belt **59** is stretched so as to contact the heat absorbing surface **34***b* along the arc surface shape of the heat absorbing surface **34***b*. As a result, in the transport path of the recording material, the belts **56** and **59** do not horizontally travel but slightly meanders along the curved surfaces of the heat absorbing surfaces **34***a* and **34***b*. Accordingly, the belt **59** of the second transport assembly **32** has a larger belt rotation resistance to slide over the cooling member **33***b* having a larger contact area against the belt **59**. By contrast, the belt **56** of the first transport assembly **31** has a lower belt rotation resistance to slide over the cooling member **33***a* having a smaller contact area against the belt **56**. The driving roller **57***a* is disposed in the second transport assembly **32** having a larger belt rotation resistance. When the belt **59** is driven by the driving roller **57***a* in the second transport assembly **32**, the belt **56** of the first transport assembly **31** is easily rotated by friction between the belt **59** of the second transport assembly **32** and the belt **56** of the first transport assembly **31**, thus reducing a difference in rotation speed between the belts **56** and **59**.

In other words, for example, if cooling members have heat absorbing surfaces of simple flat shapes, not arc surface shapes, or if a cooling member is disposed at an upper side or a lower side relative to a belt and a pressing roller is disposed at a position opposite the cooling member via the belt, the belt(s) might point-to-point contact the cooling member, not surface-to-surface contact. Thus, it is difficult to create a difference in belt rotation resistance between the two transport assemblies.

As a main factor by which the belt **56** is rotated by rotation of the belt **59**, the friction (contact resistance) between the belts **56** and **59** is conceivable. Therefore, as described above, by slightly meandering the belts **56** and **59** along the curved surfaces of the heat absorbing surfaces **34***a* and **34***b*, a difference in belt rotation resistance is created and the belts **56** and **59** tightly contact each other. Thus, the belt **56** is reliably rotated by the friction between the belts **56** and **59**.

FIG. **18** is a side view of a cooling device **9** according to an exemplary embodiment of this disclosure.

For this exemplary embodiment, in addition to the configuration of the cooling device **9** illustrated in FIG. **15**, a pressing roller **37***a* is disposed at a position opposite a position of the cooling member **33***a* via the belts **56** and **59**. Pressing rollers **37***b* are disposed at positions opposite a position of the cooling member **33***b* via the belts **56** and **59**. The pressing rollers **37***a* and **37***b* are urged by springs. The pressing roller **37***a* presses the belts **56** and **59** upward against the cooling member **33***a*, and the pressing rollers **37***b* presses the belts **56** and **59** downward against the cooling member **33***b*. Although the belts **56** and **59** contact the cooling members **33***a* and **33***b* along the heat absorbing surfaces **34***a* and **34***b*, for this exemplary embodiment, the pressing rollers **37***a* and **37***b* urged by the springs enhance the contact of the belts **56** and **59** and the cooling members **33***a* and **33***b*. The pressing rollers **37***a* and **37***b* are rotated by rotation of the belts **56** and **59** and hardly affect the belt rotation resistance of the second transport assembly **32** and the cooling members **33***a* and **33***b*. In FIG. **18**, the cooling device **9** has one pressing roller **37***a* and two pressing rollers **37***b*. It is to be noted that any other suitable number of pressing rollers **37***a* and **37***b* may be provided.

FIG. **19** is a side view of a cooling device **9** according to a comparative example of this disclosure.

For this example, unlike the configuration of the cooling device **9** illustrated in FIG. **15**, cooling members **33***a* and **33***b* have flat contact surfaces, instead of arc-shaped heat absorbing surfaces. A pressing roller **37***a* is disposed at a position opposite the cooling member **33***a* via the belts **56** and **59**. A pressing roller **37***b* is disposed at a position opposite the cooling member **33***b* via the belts **56** and **59**. The pressing rollers **37***a* and **37***b* are urged by springs. The pressing roller **37***a* presses the belts **56** and **59** upward against the cooling member **33***a*, and the pressing rollers **37***b* presses the belts **56** and **59** downward against the cooling member **33***b*. However, since the belts **56** and **59** forming a recording-material transport path are substantially horizontally disposed, the belts **56** and **59** point-to-point contact the pressing rollers **37***a* and **37***b*, respectively, rather than surface-to-surface contact. Accordingly, such a configuration may be disadvantageous in creating a difference in belt rotation resistance.

FIG. **20** is a side view of a cooling device **9** according to an exemplary embodiment of this disclosure.

In the cooling device **9** illustrated in FIG. **15** or **18**, the driving roller **57***a* has a diameter equivalent to a diameter of each of the rollers **57***c*, **57***d*, and **58**. By contrast, for this exemplary embodiment, as illustrated in FIG. **20**, a driving roller **57***a* has a diameter greater than a diameter of each of follow rollers **57***c*, **57***d*, and **58**. Such a greater diameter can reduce rotational error per rotation of the driving roller **57***a*, thus further reducing a difference in belt rotation speed caused by a difference in rotation speed. For this exemplary embodiment, for example, the driving roller **57***a* has a diameter of approximately 48 mm, and each of the follow rollers **57***c*, **57***d*, and **58** has a diameter of approximately 22 mm. It is to be noted that the values of the diameters are not limited to the above-described example but may be any suitable values.

For the cooling device **9** according to any of the above-described exemplary embodiments, the driving roller **57***a* is disposed at a most downstream side in a belt travelling direction (recording-material transport direction). Specifically, the driving roller **57***a* is disposed at a most downstream side in the recording-material transport path in the cooling device **9**. Such a position of the driving roller **57***a* allows a portion of the belts **56** and **59** forming the recording-material transport path to be drawn at a proper tension, thus further facilitating reliable contact of the cooling members **33***a* and **33***b* and the belts **56** and **59**. A follow roller **55***a* opposite the driving roller **57***a* has a diameter greater than any of other rollers **55***b*, **55***c*, and **55***d* of a first transport assembly **31** including the follow roller **55***a*. The belts **56** and **59** are endless belts including thin-film resin material, e.g., polyimide. Next, a cooling device **9** according to an exemplary embodiment of this disclosure is described with reference to FIG. **21**.



FIG. **21** is an enlarged view of two belts **56** and **59** stretched around rollers **55***d* and **57***d*, respectively.

The configuration of this exemplary embodiment is applicable to the cooling device **9** according to at least one of the above-described exemplary embodiments. As illustrated in FIG. **21**, at a recording-material entry part in the cooling device **9**, the roller **57***d* and the roller **55***d* serving as counter rollers are disposed away from each other in a recording-material transport direction. An upper end surface of the roller **57***d* disposed at a lower side is located at a position lower than a lower end surface of the roller **55***d* disposed at an upper side. As a result, a recording material P transported from a fixing device **8** smoothly enters the cooling device **9**. A roller **55***a* and a driving roller **57***a* disposed at a recording-material exit portion of the cooling device **9** has a configuration similar to, if not the same as, the configuration of the roller **55***d* and the roller **57***d*. When a recording material P enters or exits from the cooling device **9**, such a configuration prevents a fixed image borne on the recording material P from being damaged by a large burden imposed on the recording material P. A portion of the belt **56** contacting an outer circumference of the roller **55***d* does not contact a portion of the belt **59** contacting an outer circumference of the roller **57***d*. Accordingly, the belts **56** and **59** contact each other only on an area including the heat absorbing surfaces **34***a* and **34***b*. Such a configuration allows the belt **56** to be rotated mainly by friction force between the belts **56** and **59** with rotation of the belt **59**.

Next, a variation of the exemplary embodiment illustrated in FIG. **21** is described with reference to FIG. **22**.

FIG. **22** is an enlarged view of two belts **56** and **59** stretched around rollers **55***d* and **57***d*, respectively. Instead of the configuration of the above-described exemplary embodiment illustrated in FIG. **21**, the configuration of this exemplary embodiment is applicable to the cooling device **9** according to at least one of the above-described exemplary embodiments. As illustrated in FIG. **22**, at a recording-material entry part in the cooling device **9**, the roller **57***d* and the roller **55***d* are disposed away from each other in a recording-material transport direction. The roller **55***d* and the roller **57***d* are arranged to overlap each other in an upward and downward direction (i.e., a direction crossing the recording-material transport direction). In other words, an upper end surface of the roller **57***d* disposed at a lower side is disposed at a position upper than a lower end surface of the roller **55***d* disposed at an upper side. A roller **55***a* and a driving roller **57***a* disposed at a recording-material exit part of the cooling device **9** has a configuration similar to, if not the same as, the configuration of the roller **55***d* and the roller **57***d*. The belts **56** and **59** contact each other on an area including the heat absorbing surfaces **34***a* and **34***b* and a portion of the belt **56** contacting an outer circumference of the roller **55***d*. As a result, with a pressing action by the heat absorbing surfaces **34***a* and **34***b* of an arc surface shape arranged to overlap each other in the upward and downward direction, the belts **56** and **59** more intensively contact each other, thus allowing the belt **56** to be more stably rotated by friction force with rotation of the belt **59**. The rollers **55***d* and **57***d* are also disposed away from each other taking into account the thicknesses of recording materials. Such a configuration allows a recording material P transported from the fixing device **8** to smoothly enter the cooling device **9**.

FIG. **23** is a side view of a cooling device **9** according to an exemplary embodiment of this disclosure.

The number of cooling members in the cooling device **9** is not limited two but may be three or more. For example, in FIG. **23**, the cooling device **9** has three cooling members

33*a*, 33*b*, and 33*c* (collectively referred to as cooling members 33 unless distinguished). In addition, unlike the above-described exemplary embodiments, in the cooling device 9 according to this exemplary embodiment, a first transport assembly 31 is disposed at a lower side and a second transport assembly 32 is disposed at an upper side. However, the same reference codes are allocated to the same components and elements as those of the above-described exemplary embodiments, and redundant descriptions thereof are omitted below.

In this exemplary embodiment, the cooling members 33 are arranged in an order of upper side, lower side, and upper side from an upstream side to a downstream side in a transport direction C of a recording material P. The cooling members 33*a*, 33*b*, and 33*c* have substantially the same shape. The second transport assembly 32 has a greater number of cooling members (33*a* and 33*c*) than the first transport assembly 31. Thus, a total contact area of the cooling members 33*a* and 33*c* relative to an inner circumferential surface of the belt 59 is greater than a contact area of the cooling member 33*b* relative to an inner circumferential surface of the belt 56. As a result, the first transport assembly 31 has a belt rotation resistance smaller than the second transport assembly 32. The driving roller 57*a* is disposed in the second transport assembly 32 having a larger belt rotation resistance.

Here, an upper end surface of a heat absorbing surface 34*b* of the cooling member 33*b* disposed at a lower side is disposed at a position upper than lower end surfaces of heat absorbing surfaces 34*a* and 34*c* of the cooling members 33*a* and 33*c* disposed at an upper side. Here, h1 represents a distance between a lower end surface of each of the heat absorbing surfaces 34*a* and 34*c* and an imaginary line (horizontal line) K1 connecting a lower end surface of the driving roller 57*a* to a lower end surface of the follow roller 57*d*, and h2 represents a distance between an upper end surface of a heat absorbing surfaces 34*b* and an imaginary line (horizontal line) K2 connecting upper end surfaces of the follow rollers 55*a* and 55*d*. Then, the cooling members 33*a*, 33*b*, and 33*c* are arranged so as to satisfy a relation of $h2<h1$. As a result, a belt rotation resistance due to the contact of the cooling member 33*b* of the first transport assembly 31 relative to the inner circumferential surface of the belt 56 is further reliably reduced to a value smaller than a belt rotation resistance due to the contact of the cooling members 33*a* and 33*c* relative to the inner circumferential surface of the belt 59 Additionally, such a configuration allows the belt 56 to be stably rotated by rotation of the belt 59, thus reducing a difference in rotation speed between the belts 56 and 59.

In a configuration in which a plurality of cooling members is provided, the plurality of cooling members preferably has the same shape to give an effect of cost reduction by mass production. In addition, the plurality of cooling members preferably has a difference in belt rotation resistance. Hence, in this exemplary embodiment, the number of cooling members in the second transport assembly 32 including the driving roller 57*a* is greater than the number of cooling members in the first transport assembly 31 not including the driving roller 57*a*. In a configuration in which the plurality of cooling members has the same length like this exemplary embodiment, an odd number of cooling members are preferably provided in the cooling device 9 to create a difference in belt rotation resistance. By contrast, in a configuration illustrated in FIG. 15 in which the cooling members have two types of length, an even number of cooling members is provided in the cooling device 9. Alternatively, for example, two cooling members each having a length of one third of the distance L are disposed at an upper side, and a cooling member having a length of the distance L is provided in the cooling device 9 so that an odd number of cooling members in total is provided in the cooling device 9.

FIG. 24 is a side view of a cooling device 9 according to an exemplary embodiment of this disclosure.

Embodiments of this disclosure are not limited to the cooling device 9 employing the cooling-liquid circuit 44 in FIG. 5 but, for example, as illustrated in FIG. 24, the cooling device 9 may include, as cooling members, air-cooling heat sinks 106 having multiple fins, instead of the cooling-liquid circuit 44. In such a configuration, the configuration of at least one of the above-described exemplary embodiments is applicable to, for example, the shapes of heat absorbing surfaces 34*a*, 34*b*, and 34*c* and relative positions of the heat absorbing surfaces 34*a*, 34*b*, and 34*c*.

Use of the air-cooling heat sinks 106 obviates use of the cooling-liquid circuit 44, thus allowing downsizing and cost reduction of the cooling device.

FIG. 25 is a schematic view of a cooling device 9 according to an exemplary embodiment of this disclosure.

As illustrated in FIG. 25, the cooling device 9 includes a belt transport unit 30 and cooling members 33 (33*a* and 33*b*) to cool a recording material P transported by traveling of belts 56 and 59 of the belt transport unit 30. The belt transport unit 30 includes a first transport assembly 31 and a second transport assembly 32. The first transport assembly 31 is disposed at one face side (front face side or upper face side) of the recording material P. The second transport assembly 32 is disposed at the other face side (back face side or lower face side) of the recording material P. Each of the first transport assembly 31 and the second transport assembly 32 has belts 56 and 59 serving as belt members rotatably held by and stretched over a plurality of rollers 55, 57, and 58 serving as stretching members. The belt transport unit 30 also includes a pair of cooling members 33*a* and 33*b* disposed in contact with inner circumferential surfaces of the belts 56 and 59, respectively. The cooling member 33*a* is disposed at one face side (back face side or lower face side) of the recording material P. The cooling member 33*b* is disposed at the other face side (front face side or upper face side) of the recording material P.

In the cooling device 9 illustrated in FIG. 25, the cooling member 33*b* disposed at the upper side and the cooling member 33*a* disposed at the lower side partially overlap each other in the recording-material transport direction indicated by arrow C in FIG. 25. At the upper side of the cooling device 9, the belt 56 is applied with tension and brought into close contact with the heat absorbing surface 34*b* of the cooling member 33*b*. At the lower side of the cooling device 9, the belt 59 is applied with tension and brought into close contact with the heat absorbing surface 34*a* of the cooling member 33*a*. A portion of the belt 59 at the lower side that faces the cooling member 33*b* at the upper side is applied with a tension enough to prevent occurrence of a downward slack due to the rigidity of a leading end of a recording material P. Accordingly, when the belt 56 at the upper side contacts the recording material P transported, heat of the recording material P is transmitted to the heat absorbing surface 34*b* via the belt 56. The belt 59 at the lower side has a function as a guide member to guide transport of the recording material P to an area of the belt 56 at the upper side and guide a leading end of the recording material P to an overlapping area in which the cooling member 33*b* at the upper side overlaps the cooling member 33*a* at the lower side. Such a configuration suppresses striking of the leading end of the recording material against a side face (right side face in FIG. **25**) of the cooling member **33***a* and buckling of the recording material P. Thus, such a configuration prevents the recording material P from being jammed or caught at a juncture of the cooling member **33***b* at the upper side and the cooling member **33***a* at the lower side.

Next, a cooling device **9** according to an exemplary embodiment of this disclosure is described below.

In the cooling device **9** illustrated in FIGS. **26**A and **26**B, opposed cooling members **33***a* and **33***b* partially overlap each other in a transport direction C of a recording material P. Heat absorbing surfaces **34***a* and **34***b* of the cooling members **33***a* and **33***b* to contact the belts **59** and **56**, respectively, are convex, not flat. When the heat absorbing surface **34***b* of the cooling member **33***b* disposed at an upper side has a convex, curved surface, the recording material P is transported along the curved surface. The belt **59** disposed at a lower side is applied with tension. Accordingly, when the recording material P passes the cooling member **33***b* at the upper side, the recording material P starts separating from the belt **56** (cooling member **33***b*) at a separation start point SSP that is disposed between a peak PK of the heat absorbing surface **34***b* and the cooling member **33***a* at the lower side and downstream from the peak **7**A of the heat absorbing surface **34***b* in the transport direction (FIG. **26**A). At this time, since the recording material P advances in a tangential direction of a curved surface at the separation start point SSP, an upward force acts on the recording material P, thus facilitating the recording material P to be guided into between the cooling member **33***b* at the upper side and the cooling member **33***a* at the lower side.

Here, when the heat absorbing surface **34***b* of the cooling member **33***b* at the upper side has a convex, curved surface, the effect of guiding the recording material is obtained. Thus, the heat absorbing surface **34***a* of the cooling member **33***a* at the lower side may be flat. However, when both the heat absorbing surfaces **34***a* and **34***b* are convex and curved surfaces, the cooling members **33***a* and **33***b* can be formed with one type of member, thus allowing cost reduction. The belt **59** at the lower side has a function as a guide member to guide transport of the recording material P to an area of the belt **56** at the upper side and guide a leading end of the recording material P to an overlapping area in which the cooling member **33***b* at the upper side overlaps the cooling member **33***a* at the lower side.

In addition, as described below, the cooling members **33***b* and **33***a* are arranged so that the heat absorbing surfaces **34***b* and **34***a* of an arc surface shape partially overlap each other in a direction perpendicular to the transport direction C. In other words, an upper end surface of the heat absorbing surface **34***a* of the cooling member **33***a* disposed at a lower side is disposed upper than a lower end surface of the heat absorbing surface **34***b* of the first cooling member **33***b* disposed at an upper side. The belt **56** is stretched so as to contact the heat absorbing surface **34***b* along the arc surface shape of the heat absorbing surface **34***b*, and the belt **59** is stretched so as to contact the heat absorbing surface **34***a* along the arc surface shape of the heat absorbing surface **34***a*. As a result, in the transport path of the recording material, the belts **56** and **59** do not horizontally travel but slightly meanders along the curved surfaces of the heat absorbing surfaces **34***a* and **34***b*.

As a main factor by which the belt **56** is rotated by rotation of the belt **59**, the friction (contact resistance) between the belts **56** and **59** is conceivable. Therefore, by slightly meandering the belts **56** and **59** along the curved surfaces of the heat absorbing surfaces **34***a* and **34***b*, a difference in belt rotation resistance is created and the belts **56** and **59** tightly contact each other. Thus, the belt **56** is reliably rotated by the friction between the belts **56** and **59**.

In addition, since the heat absorbing surfaces **34***a* and **34***b* are convex, attaching forces (contact pressure) from the belts **56** and **59** act on the entire heat absorbing surfaces **34***a* and **34***b*, the belts **56** and **59** receive, as a reaction, a downward attaching force (contact pressure) from the heat absorbing surface **34***b*. Thus, tension of the belts **56** and **59** allows more reliable attachment of the recording material P, the belts **56** and **59**, and the cooling members **33***a* and **33***b*.

FIG. **27**A is a schematic view of belts **56** and **59** and cooling members **33***b* and **33***a* according to an exemplary embodiment of this disclosure. FIG. **27**B is a schematic view of belts **56** and **59** and cooling members **33***b* and **33***a* according to another exemplary embodiment of this disclosure.

In each of FIGS. **27**A and **27**B are shown a contact start point CSP at which the belt **56** starts contacting the cooling member **33***b* and a release start point RSP at which the belt **59** starts releasing from the cooling member **33***a*. A cooling device **9** illustrated in FIG. **27**A includes the cooling members **33***a* and **33***b* having flat heat absorbing surfaces **34***a* and **34***b*. The contact start point CSP of the belt **56** relative to the cooling member **33***b* is located at a most upstream portion of the cooling member **33***b* on an upstream side in a transport direction indicated by arrow C. The release start point RSP of the belt **59** relative to the cooling member **33***a* is located at a most downstream portion of the cooling member **33***a* on a downstream side in the transport direction C. In such a case, the cooling member **33***b* disposed at an upper side and the cooling member **33***a* disposed at a lower side overlap each other in a direction connecting the contact start point CSP and the release start point RSP. A cooling device **9** illustrated in FIG. **27**B includes cooling members **33***a* and **33***b* having convex heat absorbing surfaces **34***a* and **34***b*. In this exemplary embodiment as well, the contact start point CSP of the belt **56** relative to the cooling member **33***b* is located at a most upstream portion of the cooling member **33***b* at an upstream side in a transport direction C. The release start point RSP of the belt **59** relative to the cooling member **33***a* is located at a most downstream portion of the cooling member **33***a* at a downstream side in the transport direction C. In such a case, the cooling member **33***b* disposed at an upper side and the cooling member **33***a* disposed at a lower side overlap each other in a direction connecting the contact start point CSP and the release start point RSP. In other words, the cooling members **33***a* and **33***b* do not overlap at multiple points in different transport directions of the recording material indicated by arrows TD in FIG. **27**B during transport of the recording material (FIG. **27**B).

Next, a cooling device **9** according to an exemplary embodiment of this disclosure is described below.

In the cooling device **9** illustrated in FIG. **28**, opposed cooling members **33***a* and **33***b* partially overlap each other in a transport direction C of a recording material P. A belt **59** at a lower side has a function as a guide member to guide transport of the recording material P to an area of the belt **56** at an upper side and guide a leading end of the recording material P to an overlapping area in which the cooling member **33***b* at the upper side overlaps the cooling member **33***a* at the lower side. Heat absorbing surfaces **34***a* and **34***b* of the cooling members **33***a* and **33***b* to contact the belts **59** and **56**, respectively, are flat. Ends of the heat absorbing surfaces **34***a* and **34***b* have curved surfaces. The cooling member **33***a* preferably has an end of a curved surface at an entry side of a recording material in the transport direction C. For such a configuration, even if the belt **59** slacks and is caught on the end of the cooling member **33***a* (FIG. **29**A) when a recording material P passes the end of the cooling member **33***a* at the recording-material entry side, a leading end of the recording material P is smoothly guided upward by transport with the belts **56** and **59** (FIG. **29**B), thus suppressing transport error. As illustrated in FIG. **29**A, the radius r of curvature of the curved surface is designed to be greater than a maximum slack amount MS of each of the belts **56** and **59** in a direction perpendicular to the transport direction C, thus preventing the recording material P from being caught on a portion other than the curved surface.

By contrast, since the recording material P is generally not caught on the cooling member **33***b* upstream in the transport direction, as illustrated in FIG. **30**A, the cooling member **33***b* may have no end of a curved surface shape. However, as illustrated in FIG. **30**B, the cooling member **33***b* may have an end of a curved surface shape at an exit side of the recording material P in the transport direction C. Such a configuration allows the cooling members **33***a* and **33***b* to be formed with the same type of member.

Next, a cooling device **9** according to an exemplary embodiment of this disclosure is described below.

In the cooling device **9** illustrated in FIG. **31**A, opposed cooling members **33***a* and **33***b* partially overlap each other in a transport direction C of a recording material P. A roller **71** serving as a guide member is disposed near an end at a recording-material entry side of the cooling member **33***a* downstream in the transport direction. The roller **71** is urged by a spring and presses the belt **59** upward by an urging force of the spring. The roller **71** is rotated with travel of the belt **59**. The roller **71** guides the recording material P from a non-overlapping area to an overlapping area of the cooling member **33***b* and the cooling member **33***a*. The roller **71** also guides the recording material P toward the belt **56** opposite the belt **59** at a side at which the roller **71** is disposed. Similarly, in a cooling device **9** illustrated in FIG. **31**B, a guide plate **72** serving as a guide member is disposed near an end at a recording-material entry side of a cooling member **33***a* downstream in a transport direction C. The guide plate **72** guides a recording material P from a non-overlapping area to an overlapping area of a cooling member **33***b* and the cooling member **33***a*. The guide plate **72** has a bent shape and is disposed to slidingly contact a belt **59**. The guide plate **72** guides a recording material P toward a belt **56** opposite the belt **59** at a side which the guide plate **72** is disposed. Thus, the guide plate **72** smoothly guides the recording material P to the overlapping area of the cooling members **33***a* and **33***b*.

For example, as illustrated in FIG. **37**A, in a configuration in which cooling members **33***a* and **33***b* are arranged alternately at lower and upper sides so as to be placed away from each other in a transport direction of a recording material P, variances VA in setting angles of the cooling members **33***a* and **33***b* or other factors may cause an increased error in the entry angle of the recording material P in an area G between the cooling members **33***a* and **33***b*. As a result, a leading end of the recording material P may be transported at an unexpected angle or fluctuated. In such a case, the amplitude of the recording material P in the area G between the cooling members **33***a* and **33***b* may increase. When the recording material P moves to the cooling member **33***a* downstream in the transport direction, the recording material P may be caught on the cooling member **33***a*, thus causing a transport error.

In addition, as illustrated in FIG. **37**B, even in a configuration in which a cooling member **33***a* at a lower side and a cooling member **33***b* at an upper side partially overlap each other in the transport direction, if a recording material P is transported while fluctuating due to insufficient tension of conveyance belts **56** and **59**, the recording material P may not enter well between the cooling members **33***a* and **33***b*, thus causing a transport error.

Hence, for this exemplary embodiment, as illustrated in FIG. **31**A, there is no gap in the transport direction C between the cooling members **33***a* and **33***b*, thus preventing an increase in error of an entry angle of the recording material as illustrated in FIG. **37**A. In addition, even if the behavior of a recording material P during transport is unstable as illustrated in FIG. **32**A, the guide member (in this case, the roller **71**) adjusts an angle of the recording material P in a desired direction before the entry of the recording material P into the overlapping area of the cooling members **33***a* and **33***b*, thus preventing the recording material P from being caught on the cooling member **33***a* as illustrated in FIG. **37**B. Furthermore, the cooling members **33***a* and **33***b* partially overlap each other in the transport direction C. Such a configuration allows more downsizing than a configuration in which the cooling members **33***a* and **33***b* do not overlap each other, and reduces transport resistance as compared with a configuration in which the cooling members **33***a* and **33***b* entirely overlap each other. The configuration employing the guide plate **72** also obtains effects equivalent to those of the configuration employing the roller **71**.

Next, a cooling device **9** according to an exemplary embodiment of this disclosure is described below with reference to FIG. **33**.

The cooling device **9** according to this exemplary embodiment includes features of the above-described exemplary embodiments illustrated in FIGS. **26**A to **32**. In other words, for the cooling device **9** illustrated in FIG. **33**, opposed cooling members **33***a* and **33***b* partially overlap each other in a transport direction C. Heat absorbing surfaces **34***a* and **34***b* of the cooling members **33***a* and **33***b* to contact belts **59** and **56**, respectively, are not flat but convex. Both ends of each of the heat absorbing surfaces **34***a* and **34***b* in the transport direction C have curved surfaces. The cooling device **9** also has a roller **71** serving as guide member. The roller **71** guides a recording material P from a non-overlapping area to an overlapping area of the cooling member **33***b* and the cooling member **33***a*. Such a configuration allows more reliable transport of the recording material P in the overlapping area of the cooling members **33***a* and **33***b*.

Next, a cooling device **9** according to an exemplary embodiment of this disclosure is described below with reference to FIG. **34**.

In the cooling device **9** illustrated in FIG. **34**, three cooling members **33***c*, **33***b*, and **33***a* serving as liquid cooling jackets are arranged in an order of lower, upper, and lower sides in the transport direction C. Heat absorbing surfaces **34***c*, **34***b*, and **34***a* are not flat but convex. Here, upper end surfaces of the heat absorbing surfaces **34***a* and **34***c* of the cooling member **33***a* and **33***c* disposed at the lower side are disposed upper than a lower end surface of the heat absorbing surface **34***b* of the cooling member **33***b* disposed at the upper side. The opposed cooling members **33***a* and **33***b* partially overlap each other in the transport direction C. The opposed cooling members **33***b* and **33***c* partially overlap each other in the transport direction C. A belt **59** at a lower side has a function as a guide member to guide transport of the recording material P to an area of the belt **59** at an upper side and guide a leading end of the recording material P to the overlapping area in which the cooling member **33***b* at the upper side overlaps the cooling member **33***a* or **33***c* at the lower side. Such a configuration obtains effects equivalent to those of the above-described exemplary embodiments.

Exemplary embodiments of this disclosure are not limited to the cooling device **9** employing the cooling-liquid circuit **44** in FIG. **5**. For example, as illustrated in FIG. **35**, a cooling device **9** according to an exemplary embodiment includes a radiation facilitating part **106**. As the radiation facilitating part **106**, for example, an air-cooling heat sink having multiple fins is employed. In such a case, the relative positions between the heat absorbing surfaces **34***a*, **34***b*, and **34***c* and the belts **56** and **59** described in any of the above-described exemplary embodiments are also applicable to this exemplary embodiment. As described above, use of the air-cooling heat sink obviates use of the cooling-liquid circuit **44**, thus allowing downsizing and cost reduction of the apparatus.

Next, a cooling device **9** according to an exemplary embodiment of this disclosure is described below with reference to FIG. **36**.

For the cooling device **9** illustrated in FIG. **36**, unlike the air-cooling heat sink illustrated in FIG. **35**, the cooling member **33***b* has a flat heat absorbing surface **34***b* as a lower surface thereof, and the cooling members **33***a* and **33***c* have flat heat absorbing surfaces **34***a* and **34***c*, respectively, as upper surfaces thereof. The other configurations are similar to, if not the same as, those of the air-cooling heat sink illustrated in FIG. **35**. It is to be noted that a roller or a guide plate serving as a guide member may be disposed near an end at a recording-material entry side of the cooling member **33***b* or the cooling member **33***a*.

It is to be noted that exemplary embodiments of this disclosure are not limited to the above-described exemplary embodiments. Various modifications are possible within the scope of the above teachings. For example, at least one of the above-described exemplary embodiments is applicable to a fixing device or an image forming apparatus having any suitable configuration. For example, such an image forming apparatus is not limited to a copier or printer but may be, for example, a facsimile machine or a multi-functional peripheral (device) having the foregoing capabilities.

In the above-described exemplary embodiments, the transport path of a recording material P in the cooling device **9** is formed in a crosswise direction. It is to be noted that, in some embodiments, the direction of the transport path is not limited to the crosswise direction but may be a diagonal direction or an upward and downward direction. In the above-described exemplary embodiments, the output tray **20** is disposed immediately downstream from the cooling device **9** in the recording-material transport direction. Alternatively, for example, a post-processing device or a reverse device may be disposed immediately downstream from the cooling device **9**.

In addition, exemplary embodiments of this disclosure have, for example, the following aspects. In an aspect A of this disclosure, a cooling device includes belt rotation assemblies having cooling members to cool a recording material and belt members held by a plurality of rollers. The belt rotation assemblies are disposed opposing each other to sandwich and convey the recording material to cool the recording material. Each of the cooling members has a heat absorbing surface protruding in an arc surface shape. The heat absorbing surface is disposed on a corresponding one of the belt members to surface-to-surface contact an inner circumferential surface of the corresponding belt member. A peak surface of one of the heat absorbing surfaces at one side sandwiching a transport path of the recording material and a peak surface of the other of the heat absorbing surfaces at the other side sandwiching the transport path overlap each other in a direction crossing the transport direction of the recording material. A driving roller is disposed on only one of the belt rotation assemblies, and the other of the belt rotation assemblies is rotated by rotation of the one of the belt rotation assemblies.

In an aspect B of this disclosure, a cooling device includes belt rotation assemblies having cooling members to cool a recording material and belt members held by a plurality of rollers. The belt rotation assemblies are disposed opposing each other to sandwich and convey the recording material to cool the recording material. Each of the cooling members has a heat absorbing surface of a protruding (convex) shape. The heat absorbing surface is disposed on a corresponding one of the belt members to surface-to-surface contact an inner circumferential surface of the corresponding belt member. A peak surface of one of the heat absorbing surfaces at one side sandwiching a transport path of the recording material and a peak surface of the other of the heat absorbing surfaces at the other side sandwiching the transport path overlap each other in a direction crossing the transport direction of the recording material. A driving roller is disposed on only one of the belt rotation assemblies, and the other of the belt rotation assemblies is rotated by a friction force generated between the belt members opposing and contacting each other by rotation of the one of the belt rotation assemblies.

In an aspect C of this disclosure, a cooling device includes belt rotation assemblies having cooling members to cool a recording material and belt members held by a plurality of rollers. The belt rotation assemblies are disposed opposing each other to sandwich and convey the recording material to cool the recording material. Each of the cooling members has a heat absorbing surface of a protruding (convex) shape. The heat absorbing surface is disposed on a corresponding one of the belt members to surface-to-surface contact an inner circumferential surface of the corresponding belt member. A peak surface of one of the heat absorbing surfaces at one side sandwiching a transport path of the recording material and a peak surface of the other of the heat absorbing surfaces at the other side sandwiching the transport path overlap each other in a direction crossing the transport direction of the recording material. A driving roller is disposed on only one of the belt rotation assemblies, and the other of the belt rotation assemblies is rotated by a friction force generated between the belt members within the width of the heat absorbing surfaces by rotation of the one of the belt rotation assemblies.

In an aspect D of this disclosure, a cooling device according to any one of the above-described aspects A, B, and C also has the following configuration. That is, the center of a roller disposed at an entry part and an exit part of the recording material in the one of the belt rotation assemblies and the center of a roller disposed at the entry part and the exit part of the recording material in the other of the belt rotation assemblies are offset from each other in the recording-material transport direction. A contact portion of a belt relative to the roller in the one of the belt rotation assemblies is not in contact with a contact portion of a belt relative to the roller in the other of the belt rotation assemblies.

In an aspect E of this disclosure, a cooling device according to any one of the above-described aspects A, B, and C also has the following configuration. That is, the center of a roller disposed at an entry part and an exit part of the recording material in the one of the belt rotation assemblies and the center of a roller disposed at the entry part and the exit part of the recording material in the other of the belt rotation assemblies are offset from each other in the recording-material transport direction. The roller disposed in the one of the belt rotation assemblies and the roller disposed in the other of the belt rotation assemblies overlap each other in the direction crossing the recording-material transport direction.

What is claimed is:

**1**. A conveyance material cooling device, comprising:

a first belt to convey a conveyance material, the belt wound around rollers without a heater within a loop of the first belt;

at least one cooler within the loop of the first belt to cool the conveyance material, the cooler including a fluid flowing path;

a first upstream roller within the loop of the first belt, the first upstream roller at an entry of the conveyance material to the first belt;

a first downstream roller within the loop of the first belt, the first downstream roller at an exit of the conveyance material from the first belt, a diameter of the first downstream roller being greater than a diameter of the first upstream roller;

a second belt to convey the conveyance material together with the first belt;

a second upstream roller within a loop of the second belt, the second upstream roller at an entry of the conveyance material to the second belt; and

a second downstream roller within the loop of the second belt, the second downstream roller at an exit of the conveyance material from the second belt, the second downstream roller being downstream from the first downstream roller in a conveyance direction,

wherein the first upstream roller is disposed at a position without an opposing roller at an interior of the second belt.

**2**. The conveyance material cooling device of claim **1**, wherein:

a diameter of the second downstream roller is greater than a diameter of the second upstream roller.

**3**. The conveyance material cooling device of claim **2**, wherein a diameter of the second downstream roller is greater than a diameter of the first upstream roller.

**4**. The conveyance material cooling device of claim **1**, wherein the second downstream roller is a driving roller.

**5**. The conveyance material cooling device of claim **1**, wherein the cooler includes a contact surface to contact the first belt, the contact surface being flat.

**6**. An image forming apparatus, comprising:

the conveyance material cooling device according to claim **1**;

an image forming part to form an unfixed toner image on the conveyance material; and

a heater to heat toner on the conveyance material.

**7**. The conveyance material cooling device of claim **1**, wherein:

a liquid coolant flows in the fluid flowing path.

**8**. A conveyance material cooling device, comprising:

a belt to convey a conveyance material, the belt wound around rollers without a heater within a loop of the belt;

an upstream roller within the loop of the belt, the upstream roller at an entry of the conveyance material to the belt;

a downstream roller within the loop of the belt, the downstream roller at an exit of the conveyance material from the belt, the downstream roller being a driving roller; and

at least one cooler to cool the conveyance material, the cooler contacting an outer surface of the belt at which a conveyance path and the belt face each other, the cooler including a fluid flowing path,

wherein the at least one cooler is stationary as the belt is moving, and

wherein the outer surface of the belt contacts the conveyance material during conveyance of the conveyance material.

**9**. The conveyance material cooling device of claim **8**, further comprising a contacting roller to convey the conveyance material together with the belt.

**10**. The conveyance material cooling device of claim **8**, further comprising a conveyance guide to guide the conveyance material, the conveyance guide facing the belt.

**11**. An image forming apparatus, comprising:

the conveyance material cooling device according to claim **8**;

an image forming part to form an unfixed toner image on the conveyance material; and

a heater to heat a toner on the conveyance material.

**12**. The conveyance material cooling device of claim **8**, further comprising:

a second cooler to cool the conveyance material, the second cooler contacting an interior of the belt.

**13**. The conveyance material cooling device of claim **8**, wherein:

a liquid coolant flows in the fluid flowing path.

* * * * *